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AGRICULTURAL RESEARCH AND PLANNING: SOME LESSONS FROM THE HAWAII EXPERIENCE

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Table of Contents

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Preface

This is the fourth in a series of reports derived from a USDA Section 406, Food for Peace Act of 1966, project: Socio-Economic Criteria for Scientific Research to Improve Tropical Food Production Systems and issued by the Hawaii Institute of Tropical Agriculture and Human Resources.

The other publications are: Strategy Outline for Accelerated Agricultural Development of American-Affiliated Pacific Islands; Development of the Agricultural Sector in Hawaii; and Development of the Agricultural Sector in the American-Affiliated Pacific Islands. The cooperation and assistance of the Science and Education Administration of USDA and the Publications Office of HITAHR in the production of these reports are hereby acknowledged.

While the previous reports focused on broad developmental issues, this one is primarily concerned with the planning and research aspects of agricultural development. The first section seeks to establish a conceptual framework for decision-making on agricultural research priorities. The next section takes up a number of models, including the Hawaii Industry Analysis Program, which have been utilized for this purpose, and attempts to draw out some guidelines for an improved research decision-making process.

On the basis of the foregoing analysis and drawing upon the Hawaiian planning experience, the final section offers some suggestions for integrating research priority setting with the state planning process, with an emphasis on explicit consideration of relevant socio-economic criteria. The authors believe these may be relevant to other areas or agricultural research administration programs.

Abstract

Because agricultural research funds are typically limited, it is necessary to allocate resources to assure the highest possible returns on investment. Because they involve broad public interest as well as individual farmer objectives, they must be allocated in conformance with well-defined and acceptable goals. Planning of research programs and selection of projects should be based on clearly understood and usable criteria.

This report seeks to devise a priority-setting process which can maximize research contributions to predetermined goals. Resource allocation models proposed or developed for Iowa, developing countries, farming systems research and development, and Hawaii are analyzed for understanding of region-specific differences and to devise a common set of guidelines for research priority-setting. The Hawaii Industry Analysis Program is scrutinized further and related to requirements of the State's agricultural planning process. Finally, a revised approach to agricultural research priority-setting is proposed, integrating the State planning and industry analysis processes, and incorporating essential guidelines from review of the various resource allocation models.

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I. Framework for Decision-Making in Agricultural Research

The high returns to public investment in agricultural research in the United States, Japan and many developing countries are well documented. In Hawaii, research has contributed greatly to technological progress and growth in the major plantation industries and many of the diversified industries. It has also raised expectations with respect to future growth potential despite the many problems confronting island agriculture. Although publicly sponsored research is sizeable in Hawaii, little has been written in the local context about how research activities relate to agricultural production and the welfare of the overall community. This section presents a conceptual framework which is intended to clarify the process through which research contributes to the attainment of societal goals. In outlining the conceptual framework, the importance of appropriate information and its use for decision-making will become apparent.

A. Contribution of Research to Agricultural Productivity

Agricultural research presently accounts for $5 to $6 billion annually on a worldwide basis, with about three-quarters of this amount being spent in the developed countries. In Hawaii, the College of Tropical Agriculture and Human Resources' research budget, which accounts for the preponderant share of total agricultural research in the state, was over $11 million in 1981. The contribution of research to increased productivity and growth is now widely recognized, and consequently, research expenditures are rising, especially in the less developed countries in the tropics and sub-tropics.

Still, insufficient funding remains a problem for most of the developing countries; while developed countries spent about 2.5 percent of the value of their agricultural product on research and extension in 1974, the less developed countries (those with average per capita incomes below $1,000 in 1971) typically spent 1.0 percent or less on research (Evenson, 1978).

Scientific research results in the generation of knowledge which has varying degrees of applicability to immediate problems. Often the distinction is made between applied and basic research, with applied agricultural research being viewed as the development of new technology based on a mechanical, biological or institutional innovation; while basic agricultural research is the generation of new scientific knowledge having no particular immediate application. Basic and applied agricultural research have complementary roles. Applied research is the primary subject of this paper; but basic research is necessary for generating new technology potential, which is critical for maintaining steady growth in productivity.

Applied agricultural research for the purpose of this report encompasses socio-economic as well as biological and mechanical innovations, together with any associated developmental work required to translate the innovations into adoptable new technology. Thus, research leading to a more efficient market for a given commodity would be considered new technology in the same manner as development of an effective pesticide having no significant environmental drawbacks. Applied research may be the direct consequence of basic research done in the same geographic region or elsewhere, or it may be adaptive research which draws upon technology already developed for another social and agro-climatic environment.

Although problems of measurement and accounting for time lags have made estimates somewhat approximate, computed annual internal rates of return have been consistently high across countries and commodities, and over time. United States aggregate annual rates of return for research and extension have been estimated at 49 percent for the period 1957-62 and 34 percent for the 1967-72 period. With respect to commodities, for hybrid corn in the U.S., rates of 35-40 percent were estimated for the 1940-1955 period, and for rice in Colombia rates of 60-82 percent were estimated for the period 1957-72 (Arndt, et al., 1977). While research is but one form of investment (land, infrastructure, and equipment being other important investments), studies have shown that returns from research are two to three times as high as on other agricultural investments.

However, although many instances of successful research investments have been documented, there are instances of much lower returns and even failures for some commodities in certain countries. Thus, while the potential return is high, it is not guaranteed and perhaps even more important, the payoff to agricultural research is typically realized only over sustained periods of time. That is, considerable lag is experienced between the initial investment in research and the adoption of new technologies which produce the anticipated benefits.

The new technology generated by successful applied agricultural research results potentially in three types of benefits: (1) increased technical efficiency; (2) change in characteristics of commodities or development of new commodities; and (3) reduced production risk (less variability in yields). Technical efficiency refers to the amount of output per unit of input measured in physical terms (e.g., pounds of production per hectare). Changes in commodity characteristics benefit the farmer if such changes lead to reduced production, distribution or marketing costs, or make the commodity more valuable in the eyes of the consumer.

Benefits of applied agricultural research are not realized unless the new technology with which they are associated is adopted; thus, the research must be in tune with the needs and circumstances of the farmer, as well as the welfare of the community at large. Of course, the adoption of new technology will occur only if there is effective communication of its availability and provided that farmers perceive a clear advantage in its adoption. This is a key point which will be addressed at greater length below.

The inherent nature of agricultural research places the burden on government for its provision. Although significant amounts are spent by private industry in specialized types of research, such as for seeds, fertilizers, and pesticides, the absence of efficient markets for most research efforts results in inadequate price signals to guide resource allocation. Since it is difficult for firms to capture the benefits of agricultural research, the level of private industry investment would be too low relative to that indicated when social as well as private benefits are considered.

The significant externalities associated with agricultural research, and the resulting benefits which accrue mainly to society at large provide the basis for public investment. Because research funds are typically limited and compete with other budgetary needs, it is incumbent on government to establish priorities and allocate resources to obtain the highest return on investment. However, the process of setting priorities consistent with well-defined goals and objectives to ensure a high return on investment is extremely difficult. Given the large amounts of resources involved, periodic evaluation of research programs both before and after the fact is necessary. Measuring benefits _ex post_ to calculate the rate of return actually realized is one form of evaluation; attempting to identify, appraise, and select research projects _ex ante_ so as to attain maximum contribution in terms of predetermined goals is another form of evaluation. This report is principally concerned with the latter.

B. Goals and Objectives

Increased production and improved productivity are usually the immediate goals of agricultural research and development, while growth, equity and security considerations reflect ultimate social and economic goals. To obtain maximum benefits from resources allocated to agricultural research, there must be a clear understanding of the distinction between ends and means and how these relate to the setting of priorities.

As already noted, the output of successful applied agricultural research is new knowledge and materials, which are the means for achieving such goals (or ends) as: increased farm incomes, reduced food costs, better nutrition, increased export earnings, and rise in relative share of farm income going to labor. To the extent that research contributes positively to meeting these goals, it also contributes to ultimate social and economic goals and thus to improved human welfare.

Two aspects of the above discussion merit further elaboration. First, it is essential that final agricultural sector goals be adequately specified. If they are not, there will be little or no basis for evaluating the relative success or efficiency of the research investment. Second, although new knowledge and materials are produced through applied agricultural research, there must be a mechanism or process for ensuring that the output of research efforts results in maximum contribution to final sectoral goals. It has been noted that successful applied agricultural research potentially results in new technology which contributes benefits via increased technical efficiency, changes in commodities or new commodities, and reduced production risk. The precise form (nature of the new technology) in which these benefits are generated affects the supply of farm commodities, input demand, and on-farm farm consumption. Changes in the latter magnitudes may then be used to evaluate research contributions to sectoral and social goals. The adoption of new technology usually motivates producers to increase output since production costs are lowered, or product is more appealing and thus more in demand by consumers. However, if demand elasticities are low, producers may suffer reduced profitability unless new markets are developed or government market intervention takes place. In many less developed countries, the main problem is achieving increased farm production. In these countries, food shortfalls negatively affect human welfare, and the farm population represents a major share of total population. Thus, increased on-farm food consumption is an important policy goal. In the advanced country context, increasing commodity supply is understood to entail commensurate aggregate demand response compatible with farm sector productivity and politically acceptable levels of government support.

Matching a set of national social goals and corresponding farm sector objectives with the perspectives and priorities of research organizations comprised of scientists and other researchers, in an attempt to reach agreement on researchable problems and alternative technologies, has proved extraordinarily difficult. Ideally, research management must work closely with policymakers (at national and sectoral levels) to coordinate scientific research objectives with proposed real world technologies to maximize contributions to final goals. Practically, this has been constrained by differences in perspectives, institutional barriers, and communications and operational difficulties.

C. Socio-Economic Considerations

Socio-economic factors are of obvious importance in setting national goals and for determining corresponding development goals for agriculture; less obvious is the significance of socio-economic factors in the design of agricultural technology.

Goals established for the agricultural sector should be supportive of and consistent with national goals. Social and economic conditions, resource endowment, stage of development, and political factors all will influence the choice of national goals. Countries at an earlier stage of development will be most concerned with increasing food production--particularly that of wage goods such as the grain crops--meeting nutritional standards, raising rural labor productivity and living standards, and earning or conserving foreign exchange. In economically more advanced countries, agricultural concerns will tend to focus more on increasing farm incomes and profitability, export earnings, and development of agriculturally related industries such as food processing and packaging, fertilizers, farm machinery, chemicals, and farm services.

With respect to research policy, the key issues relate to diffusion of new technology, distribution of benefits, and social and environmental consequences of technology adoption. Scientists may develop new high-yielding crop varieties but if farmers do not adopt the innovation the research effort will be largely for naught. When this happens, the reasons are the frequently overlooked social or economic factors which make the innovation unprofitable or other wise unacceptable to farmers. Problems of this kind are much more difficult to identify, and hence more likely to occur in low income countries among small farmers. In the advanced country context, the rate of adoption and benefits of new technology are likely to be much greater to the extent that the scientists' working objectives are coordinated with underlying or related socio-economic influences.

The design and diffusion of new technology often leads to distributional consequences. Such results may be anticipated, and indeed may be the basis for policy objectives, but the point is that distributional effects are social and economic in nature; their proper anticipation requires the cooperative participation of social, biological and physical scientists in technology design. Since the direct benefits or effects of new technology occur via changes in technical efficiency, commodity characteristics, or reduced production risk, they may not be distributed equally among all producers. Also, government policies and market conditions affect the distribution of benefits between producers and consumers. In terms of technical efficiency, an innovation may be scale-biased or factor-biased. For example, a new crop variety may require the use of machinery for cultivation and harvesting. If the use of machinery is economically suitable only for larger farms, small farmers will not benefit from the innovation. The same example may be considered factor-biased if the innovation results in labor saving because of heavier capital input, i.e., substitution of machines for labor.

If a given innovation increases productivity and commodity supply expands as a result, consumers may capture a larger share of the benefits if demand is inelastic. Government economic policies with respect to taxes, foreign trade, and commodity support or purchase programs, likewise may have the effect of redistributing benefits stemming from the adoption of new technology. In some cases, when disincentives are sufficiently large to offset prospective gains from adoption, economic policies already in effect may discourage or prevent adoption of new technology.

Unanticipated social and environmental consequences of adopting new technology is another area of concern. While side effects may be both positive and negative, it is the latter which can be substantially avoided if explicit consideration of their possibility is built into the research program. Introduction of an agro-ecologically specific crop innovation in one area may result in increases in production and profits and additional market penetration, with the further consequence of farmers producing the same crop in other areas being deprived of cash incomes. Changes in cropping systems, mechanical innovations, and introduction of new crops may displace given categories of workers. These typically are low income, rural people who are relatively immobile and have few, if any, job alternatives. Introduction of modern inputs such as fertilizers and pesticides, and new cropping practices sometimes leads to unanticipated environmental damage. Again, the multidisciplinary approach which incorporates farmer participation in the technology design phase would minimize these kinds of effects.

D. Setting Priorities

Resources, both financial and human, may be committed to alternative uses. The fact that the return on investment in agricultural research has been found to be two to three times as high as on typical industrial projects is not a sufficient reason for complacency or lack of concern regarding the kinds of projects undertaken in a particular research program. It is the function of research management to ensure that the projects pursued result in maximum contribution to agricultural goals given the amount of resources budgeted. Put another way, "concurrence between the technology specification received by the scientist and the technology which results in maximum contribution to the achievement of social goals is the responsibility of research management"

(Pinstrup-Andersen and Franklin, 1977). To obtain this kind of performance, i.e., an efficient and effective program, requires that research management set priorities for the allocation of scientific expertise and funding among specific projects on the basis of established socio-economic criteria.

In many functional areas involving the expenditures of public resources, benefit-cost analysis is a technique utilized for decision-making. Total projected benefits are compared to total projected costs, and the decision to fund a project is based on the B/C ratio or the amount of net benefits. However, this traditional concept of benefit-cost analysis may be unsuitable for selecting agricultural research projects for a number of reasons.

A basic concern is that of imposing procedures for project justification which are overly burdensome to scientists. Research involves a large element of creativity, and such creativity may be inhibited if there is undue emphasis on short-run results, or excessive requirements for information and assessment of project proposals.

Defining and measuring the inputs and outputs of research is another area where the inherent nature of the subject makes it impractical to apply the conventional B/C approach. In terms of inputs, one of the most difficult problems is that of accounting for ideas contributed by researchers who are not part of an organization, but who on the basis of casual meetings, may contribute key ideas. In the same category is the valuation of research results from other countries or organizations which were publicly funded, but are considered free goods for a given subsequent project. For example, in the land-grant universities of the U.S. basic research done in many departments is regularly drawn upon in the applied research program of colleges of agriculture in the same institutions (Schuh and Tollini, 1979).

With respect to outputs, the problem is even more intractable; what constitutes relevant output is difficult to determine and measure. A chance discovery in basic research may lead to significant applications in several areas, as already mentioned, but attaching value to specific basic research findings is virtually impossible. When the research results in increased production or inputs saved, the benefits may be estimated, but when it leads to changes in the characteristics of commodities, or in reduction of production risk, the valuation of benefits is much more difficult.

A further problem is applied research may be successful in terms of meeting specified objectives, but the results may not be adopted. In this case, conventional analysis would suggest assignment of a negative value to the project. However, it is recognized that training and education are associated with the research effort, and even for "unsuccessful" projects, skills may have been attained and graduate education may have been advanced. These are examples of joint outputs which are benefits, but difficult to evaluate in the context of *ex ante* project evaluation.

Other significant outputs which are difficult to evaluate are research which leads to better price incentives to farmers, and policy research which eliminates or reconciles inconsistent economic policies and leads to an increase in agricultural output from a given set of inputs (Schuh and Tollini, 1979).

Where a narrow B/C analysis approach is not appropriate, a more flexible evaluation of benefits and costs of proposed projects in a framework comprised of goals and objectives, criteria, and a corresponding priority setting process may be the best way to achieve an efficient and effective research program.

II. RESOURCE ALLOCATION MODELS

Several states and some individual researchers have experimented with a variety of formal systems intended to improve the decision-making process for selecting particular projects from the overall portfolio of possible research endeavors. These resource allocation systems are typically referred to as models, but most such models are essentially information gathering systems structured to facilitate allocation decisions by utilizing informed judgement in accordance with prescribed procedures. A few models attempt to provide quantitative feedback on the consequences of a particular innovation or change in government policy. The latter are models in the more conventional sense and require considerable investment or resources in developing the mathematical structure and corresponding computer programs needed to obtain results.

This section takes up: (1) the Iowa model, first developed during the U.S. federal and state program planning and budgeting era of the '60's; (2) a model developed by Pinstrup-Andersen and Franklin for possible application to less developed countries; (3) Farming Systems Research and Development (FSR&D), a concept advocated by such international assistance agencies as USAID and World Bank and utilized by a number of international and national agricultural research agencies focusing on developing country issues; and (4) the Hawaii Industry Analysis Program, devised by the College of Tropical Agriculture and Human Resources (CTAHR) to meet state resource allocation needs. For a more detailed exposition of resource allocation models developed for agricultural research, the reader is referred to Arndt, Dalrymple and Ruttan (1977), Schuh and Tollini (1979), Fishel (1971), Minnesota Agricultural Experiment Station (1981), Shaner, Philipp and Schmehl (1982).

A. The Iowa Model

One of the first models developed to assist agricultural research resource allocation at the state level was the Iowa Model (Mahlstede, 1971; and Paulsen and Kaldor, 1968). Increased agricultural research funding, more complex problems, and greater specialization motivated the desire for a more systematic and consistent method of selecting research proposals. The first task of the Iowa Experiment Station was to establish the goals against which proposed research alternatives would be evaluated. It was recognized that the benefits of specific research efforts must be evaluated in terms of their contribution to collective goals; therefore, three social goals--growth, equity, and security--were established. Research alternatives were to be judged in terms of their contribution both to state and national growth, equity, and security goals.

The basic approach of the Iowa Model was to estimate for each research alternative the discounted present value of total contributions (benefits) to each social goal, and compare this with the discounted present value of the total costs necessary to produce the contribution. That is, conceptually, a ratio of benefits to costs was calculated for each specific research alternative. For example, with respect to the growth goal, the contribution of a technical innovation would be the expected cumulative discounted value of the resources saved by farmers in producing a commodity of a given market value taken as a ratio to the cumulative discounted costs expected to be incurred to realize the resource savings.

To make the evaluation system operational, the range of responsibility of the experiment station was divided into nineteen specified commodity, resource, and management research areas.* For each area, a panel of station professional staff, including scientists, department heads, and administrators, was designated. Composition of each panel cut across department and discipline lines. Instructions and forms for making systematic evaluations were distributed and explained to each panel member. In the initial experiment station evaluation effort, only the state and national growth goal was addressed.

Each panel member was first requested to make a list of potential research activities that would result in specific packages of new knowledge, judged to have potential for making large contributions to growth. Growth could be obtained via three routes: Type I research opportunities, which generate new technical knowledge resulting in a reduction in per-unit production costs; Type II research opportunities, which generate new knowledge resulting in increases in commodity value, i.e., quality changes which lead to wider range of uses or superior characteristics; and Type III research opportunities, which produce knowledge leading to increased utilization of existing technology and a consequent reduction in resources needed to produce a given physical volume of output (for example, the elimination of economic disincentives preventing the use of production inputs such as imported equipment or fertilizers).

Members submitted proposed research alternatives, and each of the nineteen panels discussed each proposal. The task of a panel at this stage was to prepare a master list of research alternatives. To do this, screening was necessary to eliminate duplicative research, consolidate overlapping activities, and to eliminate alternatives which were considered inappropriate because of ongoing

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*These were: corn and sorghum; soybean; small grain, forage, and pasture; horticulture; forestry; swine; beef; poultry; dairy; fish and wildlife; outdoor recreation; human resources; soil and water; air and climate; farming sector and rural household; agriculturally related business and rural service organization and management; farm and agriculturally related markets; farm commodity processing and distribution; and foreign agricultural development.

or planned research in other institutions. In preparing the master list, it was necessary for each panel to insure that the package of information or questions to be answered on each research alternative was adequately specified so that it was clear what the expected research product was to be and what was expected to be completed within a given (say five-year) planning and budgeting period.

Once each panel had completed its master list of research alternatives, it collectively evaluated each in terms of the station's ability to produce the package of new knowledge; nature of problem, stock of related knowledge needed, professional staff requirements, and availability of research materials and facilities were factors taken into consideration. From this evaluation, the panel made a judgment on the probability of success of generating the specified new knowledge of each alternative. Similarly, the panel estimated the costs of both generating the new knowledge and putting it into the form necessary for adoption, including costs of dissemination. In estimating the costs of each research alternative on the master list, the costs of alternative methods of producing the new knowledge were also considered.

The research alternatives proposed by each panel ranged from very basic to applied research only one step removed from direct application as new technology. The more basic the research, the more indirect is the potential application of the new knowledge in terms of adopted new technology which results in resource savings. The problem for the panels in dealing with the more basic research alternatives was how to estimate the probability of ultimate success in their application to new technology. Even if probability of success might be considered low, expected benefits could be quite high because of the very large resource savings in the event new technologies were adopted.

To arrive at rankings of the research alternatives by each panel, individual panel members were requested to consider ten criteria in establishing the rank of each alternative on the master list. While the ranking procedure was systematic, it was not quantitative in that each member was not required to calculate the growth contribution and probability of success of each alternative. The criteria to be considered by each panel member in arriving at his or her ranking were as follows: (1) probability of a successful outcome; (2) anticipated resources saved by producers using the new knowledge in final form; (3) the time over which resource savings would occur; (4) any indirect benefits to other commodities or resources that might result from the research; (5) the direct cost of doing the research as estimated by the panel; (6) time needed to complete the research; (7) cost of any associated research development effort needed to put the specific package of new knowledge into final form for adoption; (8) the probability that (7) would be undertaken and, if undertaken, would be successful; (9) the degree and speed of adoption; and (10) the public extension cost and time involved in achieving adoption. No weighting scheme was specified, and individual panel members were free to use their own judgment in weighting the criteria. Also, each panel member was to rank each research alternative on the basis of its contribution to growth in Iowa, and in terms of contribution to national growth.

After each member had ranked the research alternatives, a consensus panel rank was determined by simply summing the ranks assigned each alternative by the members. The panel then collectively considered the aggregate rankings of the alternatives and noted which specific alternatives had the most variability in terms of the individual rankings assigned. An attempt was made to determine the reasons for the variability in individual rankings for given research alternatives. Members were then given the opportunity to revise their rankings if they so desired. After this, final aggregate rankings were determined by the panel in the same manner as before (by summing each member's rank for a given alternative), and the ranking results were turned in, thus completing Phase 1 of the evaluation.

In Phase 1, only the panel rankings of research alternatives in terms of the contribution to the growth goal were sought. Phase 2 involved the same nineteen areas, but membership on the panels was changed, and their task was to rank research alternatives with respect to the goals of equity and security. The list of research alternatives to be considered by each panel with respect to each goal may differ from those considered in Phase 1 and also may differ as between the two goals of Phase 2. The same procedures were to be followed in the ranking process as in Phase 1, but the final outcome for each panel was to establish a single master list of research alternatives in rank order. In Phase 3, the nineteen panels (now comprised of department heads and selected panel chairmen) were to aggregate across panels and across goals. In the final step of the planning and evaluation experiment, a five-year plan with three different budget levels was to be prepared incorporating the research alternatives assigned the highest priorities as a consequence of the evaluation and ranking process.

At the time that the Iowa Model experiment was reported, Phases 2 and 3 had not been undertaken. However, based on the experience of completing the Phase 1 ordering of research alternatives with respect to the growth goal for Iowa and the nation, a number of points seem pertinent.

It was explicitly recognized that research conducted by the experiment station should be considered a social investment; thus the demand for new knowledge was not seen as a final product, but as an instrumental means to achieve social goals. The relevant goals were those of the public which support the station, i.e., the citizens of Iowa and the nation, as both state and federal funds are involved. The efficient use of public monies requires some means for evaluating proposed research to insure that the projects selected will result in new knowledge which makes a maximum contribution to specified goals relative to costs incurred.

This central point, together with the inherent difficulty in predicting probability of success and specific benefits of proposed research, makes it mandatory that the working scientists participate in the evaluation of proposed research alternatives. Moreover, the exercise of making a concerted multi-disciplinary effort to identify potentially high payoff research alternatives was seen as a valuable spinoff of the evaluation experiment.

The extremely demanding time requirements of this process had the practical effect of simplifying the evaluation methodology. In terms of both goals and quantification of variables, changes were made to reduce the level of effort. With respect to goals, the importance of specifying goals at appropriate levels which were internally consistent was recognized. However, the necessity of coping with the difficult weighting problem resulted in retaining only the three higher level goals of growth (in income), equity, and security. Even with these three goals, the experiment was carried through in detail only with respect to the growth goal. Likewise, in terms of quantification, it had originally been anticipated that the growth contribution would be estimated for each research alternative, along with cost and probability of success. While each panel collectively estimated cost and probability of success, the final rankings were determined on the basis of individual qualitative judgments with respect to the ten criteria.

Another point worth noting was the difficulty and concern expressed by many that there seemed to be an unavoidable bias in evaluating the more basic research alternatives compared with the applied research alternatives. The more basic the research, the less direct the ultimate application of the results and the more difficult it is to specify a probability of success. In this situation, a low probability is typically assigned the basic research alternative. It was felt that given the procedures for ranking the projects, low probability of success projects would inevitably tend to be ranked low compared with high probability of success projects.

A final note of concern was that attempts to develop improved research management techniques must guard against the risk of stifling the creative processs. That is, requesting too much in terms of time involvement of scientists could adversely affect morale and the effectiveness of the research program.

B. A Developing Country Model

In contrast to the Iowa review panel scoring model, is the approach taken by Pinstrup-Andersen and Franklin (henceforth referred to as the PAF Model), which utilizes a quantitatively specified systems approach. Although specifically designed for application in a developing country (Latin America) context, the PAF Model incorporates certain elements, which may be considered extensions of the Iowa Model approach.

For purposes of the present report, the significant elements of the PAF approach are first, its emphasis on development of a suitable goal structure, with linkages among higher level goals, intermediate goals, and specification of working objectives for the research program; and, secondly, its delineation between alternative potential (research alternatives) technologies and their expected impacts.

The relationship among goals and objectives is schematically shown in Figure 1. In the PAF Model, the same ultimate or higher level goals of growth, equity, and security were established as in the Iowa Model. While these goals may be considered universal in that they represent basic ingredients of human welfare among countries or regional political entities, differences in relative emphasis and further specification within each goal are to be expected. In the PAF Model, the following social goals were included: (1) economic growth; (2) more equitable income distribution; (3) increased productive employment; (4) increased net incomes to small farmers; (5) a more even cash flow to farmers; (6) improved human nutrition; (7) a higher degree of self-sufficiency in basic foods; and (8) increased foreign exchange earnings. These goals would be those typically found in Block A of Figure 1.

The contribution of the agricultural sector to these national goals must come via changes in commodity supply (amount, kind, composition, and price), farm input demand (amount, kind, and prices of labor, capital, land and other inputs), and domestic consumption (amounts, kind, and composition). It must be remembered that the PAF Model was designed for the developing country context, and thus domestic (on-farm) consumption is specifically considered in Block B.

Once overall social goals have been set, the problem becomes one of determining the best course for the agricultural sector to pursue, given the specified goals. Thereafter, the role of agricultural research may be assessed to determine specific ways for relieving or removing restraints to development through the generation of useful technology.

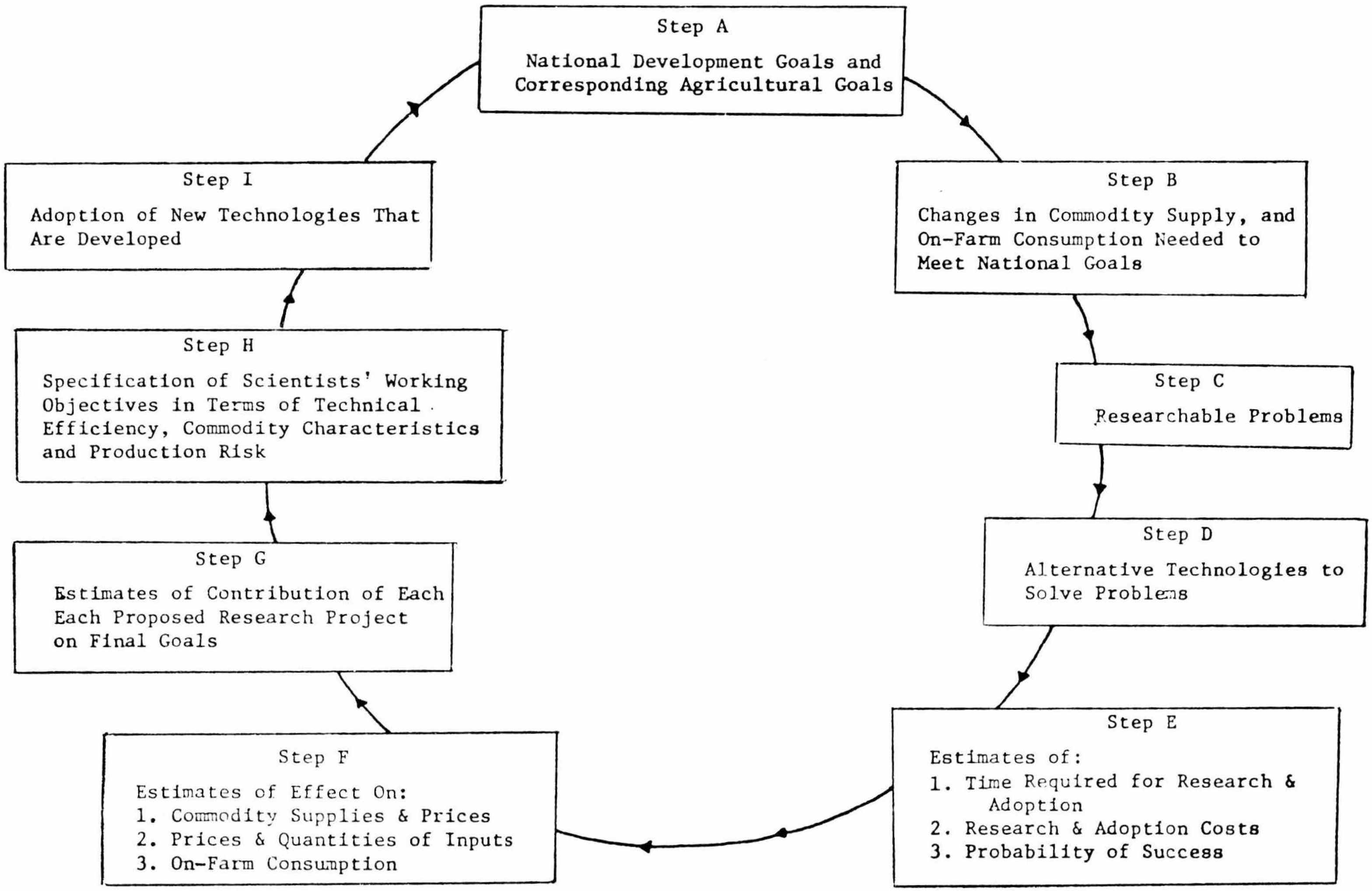
Viewed in this way, it is clear that the collaboration of social, biological and physical scientists will be necessary to identify relevant researchable problems (Block C). For example, an increase in a given commodity output is judged desirable to improve nutrition and provide greater self-sufficiency, but increasing the supply must come primarily through increases in yields. The technological alternatives available for raising yields have differing input requirements, and depending on the choice, could have adverse effects on the environment, income distribution, or could have a low adoption rate because of seasonal labor requirements. Selecting the best technology in light of farm sector conditions and social goals would require a multi-disciplinary approach.

In identifying researchable problems, it has been noted that the problems should be expressed independently of the possible technology for their solution. This will help insure that all possible alternative technologies are considered in selecting that which maximizes the expected contribution to goals relative to cost. Blocks D and E, the consideration of possible alternative technologies (the research alternatives expected to produce the new technologies), and the estimation of costs, time, and probability of success are steps analogous to those of the Iowa Model.

The next step, the estimation of the impact of each research alternative for a given problem (Block F of Figure 1), corresponds to that of estimating

FIGURE 1

Translation of National Development Goals Into Scientists' Working Objectives for New Technology



Source: Adapted from Pinstrup-Andersen and Franklin, "A Systems Approach to Agricultural Research in Developing Countries," Figure 20-2, in Arndt, et.al., 1977.

the growth contribution in the Iowa Model. However, in the PAF approach there is a substantial difference: impacts on commodity supply, input demand, and domestic consumption are transmitted by changes in technical efficiency (productivity increases), commodity characteristics, or production risk. In the Iowa Model experiment, the growth contribution (resources saved) was equivalent to technical efficiency, but contributions to growth that might occur via changes in product characteristics and production risk were not estimated. Also, the PAF Model utilized a mathematically specified model (computer-based simulation model) to estimate empirically the expected changes as a consequence of each alternative new technology. In other words, given the model, each research alternative could be simulated to determine its estimated impact. The availability of the model would eliminate the burden of the scientists' estimating separately the impacts of each alternative. Of course, this abstracts from the very large amount of resources that have to be invested up front in developing the simulation model before it can be used, and there is always the question of how accurate or well validated the model is vis-a-vis the real world it is supposed to depict.

However, without the burden of estimating the contributions to goals of each research alternative, the scientists are able to spend more time on identifying researchable problems, specifying alternative potential technologies, and estimating the change in technical efficiency, commodity characteristics, or production risk of each alternative. The simulated impacts can provide clues as to which alternatives might make the largest contributions to final goals per research dollar invested. With multiple goals, however, there is still the problem of weighting, either by reaching decisions through subjective consideration of tradeoffs, or by utilization of a predetermined weighting scheme.

Based on scientists' estimates of the nature and extent of technical change expected in each alternative, and simulating each change by utilizing the model to measure the impact on the economy, a set of alternatives consistent with the research budget is selected (Block H, Figure 1). Having already estimated the expected technical changes of each alternative, scientists already have a set of working objectives to guide them in actually undertaking the research.

While the PAF Model correctly emphasizes the importance of a well specified and consistent goal structure, and underscores the necessity of translating higher level goals into working objectives for scientists, many aspects of the technology development process are over-simplified. An obvious difficulty already noted would be the very large amount of time, expertise, and funding required to construct and maintain the simulation model. Generating quantitative estimates of potential impacts is insufficient; probability of success and weighting in terms of multiple goals must still be factored in.

Even if a large scale quantitative model can be developed for a given economy, it still is no easy task to identify a priori those commodities, resources, and agricultural sector systems which should be focused upon to identify relevant researchable problems. In the absence of the model (and the learning that goes into construction and using it), this task (Block B, Figure 1) becomes very large indeed.

Another facet of the model which may be somewhat misleading as presented is the single direction, step-by-step progression depicted in Figure 1. In actuality, one must expect a large amount of back-tracking (feedback) as problems and potential alternative technologies are re-specified, adjusted, or the problem areas re-assessed.

An area which appears to be neglected is that of basic research. The PAF approach seems applicable only to applied research. The assumption presumably is that a stock of knowledge relevant to agriculture is available (supplied by the international institutes or by the national agricultural research systems of the more advanced countries) and can readily be drawn upon to generate researchable problems.

A final point in regard to the PAF Model relates to the necessity of obtaining farm sector data. Establishing effective communications with farmers, especially small farmers in the less developed countries, and working at the farm level to understand the production systems and problems is highly important if relevant researchable problems are to be generated, and if new technology is ultimately to be adopted. Particularly with respect to the effects of economic policy, marketing problems, incentives, and social problems, adequate knowledge of farm level circumstances is important--even in the advanced country context.

C. Farming Systems Research and Development (FSR&D)

1. Distinguishing Characteristics

An attempt to confront this last problem may be found in the Farming Systems Research and Development approach (FSR&D), widely advocated by international assistance agencies and increasingly utilized or experimented with by international and national agricultural research agencies. Devised to deal with problems of the rural poor in less developed countries--more specifically, to focus agricultural research on needs of small-scale farmers with limited resources--FSR&D is distinguished from other research approaches in two major respects.

First, it is an holistic approach, viewing the farm as a comprehensive whole with explicit recognition of interrelationships within and between the natural and social environments in which it operates. This contrasts with the traditional reductionist approach, which seeks to reduce complex problems into narrower areas in a research environment more or less under the control of research scientists, with results evaluated by a peer review process. Thus, FSR&D by its holistic nature virtually requires consideration of socio-economic characteristics--the social goals, interactive components, and environmental constraints--that govern or affect agricultural enterprise.

Second, FSR&D emphasizes "on-farm" or "downstream" research. This is not that the bulk of the research must be done by farmers or on the farm as such, nor that traditional experiment stations be closed down. Rather, it implies that the research effort will focus on devising strategies that will improve the productivity of farming systems and meet other short-run needs of target groups of farming families. This requires working directly with farmers in identification of research needs, conduct of experiments, and testing, evaluation, or application of results. The lesson was learned in various developing countries, where it was found that technologies derived from "upstream" or "top-down" experiment station research were rejected by small farmers as being unprofitable, too risky, or otherwise unsuitable to their conditions.

Further, in contrast with the other models described in this report, FSR&D is concerned with the entire research process--target and research area selection, problem identification, information gathering and data base, research project design, experimentation and analyis, and extension of results--not solely the setting of priorities for research resource allocation. However, both the holistic and downstream aspects are such as to require explicit attention to establishment of research priorities, and this will be the focus of the subsequent discussion.

2. Definition, Functions, Process

More formally, FSR&D may be defined as an approach which views the whole farm as a system and analyzes the interdependencies among components under control of the farm household and how these components interact with physical, biological, and socio-economic factors not under its control.* The farming system under study is thus a complex arrangement of soils, water resources, crops, livestock, labor, other inputs and resources within a natural and social environment, which the farm household manages in accordance with its preferences, capabilities, and technologies.

FSR&D typically relies on interdisciplinary teams to perform its functions. Prominent in its staffing are field teams, normally living on or near the research or target areas. These teams may be augmented by disciplinary specialists in biological, physical, and social sciences, who operate in the target areas, at experiment stations, or from regional or national institutes. Overall responsibilities of the teams are to: (1) understand the multi-facets of farm operation through close contact with household members; (2) recognize farm problems or opportunities from an holistic view; (3) recommend or set priorities accordingly; (4) evaluate findings or results in terms of the farming system and society as a whole.

The FSR&D process in turn involves:

(1) Selection of research areas and target groups with reasonably similar characteristics so that any improved technologies may be utilized by farmers throughout and occasionally outside the target area;

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*This definition and much of the subsequent discussion of FSR&D is drawn from Shaner, Philipp and Schmehl (1982).

(2) Identifying, ranking, and hypothesizing researchable problems through review of available information, direct observation and on-farm discussion, and early-on reconnaisance surveys;

(3) Conducting additional surveys, experiments, and studies to reformulate research problems, revise priorities, test hypotheses, develop the data base, and formulate the research agenda;

(4) Carrying out on-farm experiments and research studies to develop improved technologies suitable to farmer needs and conditions, with focus on biological performance, resource requirements, economic feasibility, and socio-cultural acceptability;

(5) Coordinating the downstream experiments and studies with upstream commodity and disciplinary research to fill information gaps, overcome research deficiencies, and faciliate farmer-researcher linkages;

(6) Evaluating farmer acceptability of resulting technologies, extending results widely to farmers within and without the target area, and encouraging public support for program recommendations.

It should be noted that FSR&D does not require that these activities be undertaken in sequence nor that one stage must be completed before the next commences. Rather, the process is iterative and dynamic in that research results feedback to earlier stages to help improve subsequent activities and also become the basis for new targets, strategies, and actions. In this process, the need for research priority-setting criteria arises particularly during the problem identification and agenda formulation stages (activities 2 and 3 in the above schema).

3. Criteria for Problem Identification and Research Planning

Although enough may be known about a target area to proceed directly to planning and formulating the research agenda, Shaner, Philipp and Schmehl advise against by-passing the problem identification stage (p. 62). They recommend at least a first pass through problem identification, culminating in a set of well-defined problems ranked in accordance with the following criteria:

(1) Seriousness of the problem as viewed by both farmers and society;

(2) Potential for solving the problem, gaining acceptance of the solution, and implementing the results;

(3) Importance of the problem in terms of an overall research strategy.

Although FSR&D lends itself to conceptual modelling and eventual quantification, the recommended priority-setting approach is essentially qualitative or judgmental. Thus, in evaluating the seriousness of a problem, farmers will be concerned with its severity and frequency in terms of farm household activities, while public policymakers will note its broader impact throughout the target area. Where the interests converge, a high priority may be assigned. Where the interests diverge, two possibilities emerge. If there is an overriding public interest, a high priority may be assigned with a proviso for additional study of incentives for farmer compliance. If the problem is in the interest of farmers alone, it may remain a low priority item, with perhaps some attempt to persuade farmers to conform to the public interest.

In terms of potential for solution, priorities may be based on biological potential, resource availability, economic and financial feasibility, and sociocultural acceptability. Here the key judgmental questions might be: Do the physical and biological conditions in the research area provide opportunities for problem solution? Will potential solutions reduce utilization of scarce resources or increase employment of underutilized resources? Will benefits of potential improvements offer sufficient incentives to interest farm households?

Will they increase or decrease stability of farm production and income? Will community values, norms, and customs help or hinder acceptance of proposed solutions?

The FSR&D process should lead ultimately to formulation of research strategies in which sequential or complementary relationships among problem solutions may be conceptualized. If an individual research problem can be identified as part of an overall strategy, a high priority can be assigned. However, in the early stages of FSR&D, such strategies are likely to be highly provisional and subject to continuing feedback as the process evolves and thus of lesser importance in a priority-setting process.

This initial ranking of researchable problems and opportunities establishes the basis for the subsequent research effort. The same or similar set of criteria may be used throughout the FSR&D process, with perhaps a sharpening of focus, greater emphasis on detail, and perhaps some quantification. The knowledge gained of farm households and farming systems, the environment in which they operate, and technologies they are able to utilize thus enable the FSR&D team to produce a research work plan acceptable to target groups and suitable to broader social imperatives. Further, this knowledge obtained and refined during the problem identification stage, and indeed throughout the FSR&D process, becomes the basis for setting research objectives, selecting appropriate methodology, coordinating efforts of experiment stations and other agencies, and further refining the team's tasks and responsibilities.

4. Should FSR&D be instituted?

The remaining and dominant question for policy-makers at national, state, or regional levels is: whether, when, or under what conditions should FS$&D be instituted? Its advocates contend that by shifting the research focus downstream to the farm, potential technologies can be more readily evaluated for conformance with national goals as well as improvement of farming systems. They provide ample examples of how the approach has improved small farmer productivity in developing countries through modification of existing systems (i.e., better use of available technology) or introduction of new farming systems (i.e. generation of new or more appropriate technology) (Shaner, Philipp, and Schmehl, pages 164-165). They also point out that where proposed technologies do not contribute significantly to social goals, they may be readily set aside for those that do.

Policymakers, however, will also be concerned with such issues as organizational capacities and constraints, personnel requirements, budgetary impacts, and comparative cost-effectiveness. Introduction of new systems or approaches must immediately confront the problem of how they might be digested or assimilated by existing organizational capacity or whether they are likely to be submerged or diluted by the established bureaucracy. For new programs, personnel requirements and availability are likely to be strategic concerns. In terms of budgetory impact, new programs will be competing with long-established agencies and face modest beginnings unless complementary or sequential phasing procedures are worked out.

Cost-effectiveness is more than likely to be a major policy concern. Governments will have invested substantial amounts over time in the more traditional experiment station or agricultural research institute approach, and rates of return can be calculated. FSR&D as the "new kid on the block" will require comparatively high start-up costs and long gestation periods for returns on investment to be realized and calculated. Its advocates cite the counter-argument that traditional experiment station and newer FSR&D expenditures should be regarded as complementary and the relevant question is: What combination of the two can come the closest to meeting national goals and individual objectives in the most compatible manner?

For developing countries and also states and regions of more advanced economies, the overriding consideration for possible FSR&D will probably be political. That is, what is the current status and likely future role of the small farmer in terms of social goals or national objectives. For areas that are committed to commercial production for export purposes, future research support will continue to go largely to traditional agricultural research and extension programs, since these have usually served the commercial interests well. For nations, states or regions that seek a continuing and viable role for small-scale farming, for either commercial or subsistence purposes, FSR&D may provide policymakers with a systematic means of validating this role. In addition, the FSR&D emphasis on target groups and geographical areas can provide political figures with explicit outlets for disbursement of public funds as well as a focus for measurement of benefits, if this should prove the case.

D. The Hawaii Industry Analysis Program

The Hawaii Industry Analysis Program (IAP) was developed in response to the need for information on the relative importance and potential of the various agricultural commodity industries. This became apparent in the mid-1970's when the State Administration and Legislature began to implement a policy designed to strengthen the agricultural sector and promote increased growth in the diversified agriculture industries. In September 1976, CTAHR agreed to be the lead agency in making systematic assessments of each agriculture industry (CTAHR Memorandum, December 1976). The first analysis was completed for the pineapple industry in 1977.

As of July, 1981, CTAHR had coordinated and participated in the completion of at least one analysis for each of eighteen industries (Table 1). Some of the eighteen commodity or resource industries have been analyzed a second time. In addition to developing the methodological approach utilized in analyzing an industry, CTAHR has closely worked with each industry and other government agencies in organizing and carrying each analysis through to completion, a process often taking a year or more to complete.

Broadly speaking, the purpose of the industry analysis program is to enable a specific commodity or resource industry to assess its own status and growth potential and the problems it must overcome to achieve this potential. With this assessment or analysis, priority problems can be identified and public and private resources allocated to resolve them. The distinctiveness of this approach is in its heavy reliance on private sector participation in setting research priorities, while the Iowa and PAF models depend more traditionally on scientist-research administrator judgments. With industry participation, essential farm level information is made available. Without this kind of microeconomic, technical and social input, it would be virtually impossible to identify all of the significant factors restraining growth in the agricultural sector and particularly within a given commodity or resource area. However, as will be seen, the full value of the program is not in the provision of essential planning information, but as a basic component in an overall planning, resource allocation and program implementation process. The Hawaii IAP resembles FSR&D in its emphasis on private farm sector participation, but differs in that farmers are brought part way "upstream" for meetings at experiment station sites and are likely to be larger-scale commercial producers or scientists employed by agri-business operations.

1. Initiation of an industry analysis

In the early months of the program, the industries to be analyzed were those of primary interest to the legislative committees dealing with agriculture and to the Governor s Agriculture Coordinating Committee (GACC). At the present time, an analysis is typically initiated after spokesmen for a given industry approach the CTAHR to express an interest in having an analysis done. The college dean or associated administrator explains what is involved in conducting an analysis, and how the results are to be used. The degree to which an industry is organized and in agreement on the benefits to be derived from the analysis has a bearing on whether the decision is made to proceed. The structure and nature of the industry and commodity produced (or resource used), in turn, plays a large part in determining how the analysis will be structured. To date, most of the analyses have dealt with marketable commodities which have been relatively easy to define in terms of data availability, definition of producer, and market coverage. The CTAHR intends to address resources also, including input resources such as water, human resources, and land. Obviously, the initiation of such analysis and the methodology used will differ from that of the typical commodity industry. The description below relates to the approach used for commodities such as pineapple, beef, guava, and protea.

2. Elements of the Analysis Process

Essentially, the program is unstructured and, indeed, is not formally recognized in terms of budget and funds or personnel resources committed to the analyses. The CTAHR administration asks industry, college, and other

TABLE 1

Status of Agricultural Industry Analyses*
July 1981

COMMODITIES	PLANNED	IN PROCESS	COMPLETED
Agroforestry, Forests & Natural Resources			Feb. 1981
Anthuriums			Mar. 1980
Banana			Sept. 1980
Beef and Pasture			May 1981
Dairy			July 1981
Dendrobiums			Jan. 1981
Guava			May 1979
Leafy Vegetables			May 1980
Macadamia Nut			Mar. 1981
Ornamental Potted Plants			June 1979
Papaya			Mar. 1979
Passion Fruit			Feb. 1978
Pineapple			June 1979
Poultry & Eggs			Oct. 1979
Protea			Dec. 1978
Sugar			June 1980
Swine			Sept. 1979
Taro			Mar. 1980
Aquaculture		X	
Feed, Forage & Corn		X	
Solanaceous & Cucurbit Crops		X	
Turf & Landscape		X	
Avocado	X		
Coffee	X		
Other Cut Flowers	X		
Root Crops	X		

*Reproduction of Table 11, p. II-76, State Agriculture Plan, September 1981.

government (state, local and federal) individuals with relevant technical or policy expertise to contribute to specific analyses on a voluntary basis. After the initial discussions with industry spokesmen and decision to do an analysis, CTAHR administration designates an analysis group leader. This is typically a member of the college faculty who has scientific expertise related to the commodity in question. Upon designation of the group leader, a worksheet on the industry is prepared, a meeting with the industry is held, an analysis and action sheet are completed, and the industry-endorsed results are presented to the GACC. The process and components are discussed below.

a. Worksheet

The first step in preparing an industry analysis is the drafting of a worksheet. Usually the analysis group leader or one or more persons working under his or her direction write the worksheet draft. The initial draft is actually a discussion paper which is intended to set forth the commodity industry's current status and potential. The worksheet describes the industry's current situation, its potential based on stated assumptions, and the component parts of the industry. It presents a working system or model of the overall process by which factors of production are combined to produce the commodity, and through which it is subsequently handled, processed, and distributed to the consumer.

Along with the drafting of the initial worksheet for discussion purposes, a list of individuals capable of contributing to the industry analysis is compiled. In addition to CTAHR faculty and staff, these individuals may be active members of the industry being analyzed, or may be with relevant state, county, or federal agencies. The listed individuals are contacted, usually by letter or memorandum, and requested to participate in the industry analysis. Persons volunteering to join the analysis group may contribute either by submitting written material on specific portions of the analysis, or by verbally communicating information to a drafting coordinator who is writing a part or all of the worksheet, analysis, or action sheet.

In terms of the structure and content of the worksheet, one of the important initial tasks is to break the industry down into significant components, which may be associated with critical constraints or bottlenecks. Many of the components of an industry are common to all industries; i.e., land, water, labor, capital and transportation. Other components such as cultivars, insect control, and waste management are relevant or significant only with respect to certain industries. Exhibit 1 is an example of the tabular format used in presenting the analysis results. In this instance, the disease control component of the solanaceous and cucurbit crops (tomato, pepper, cucumber and specified similar crops) is shown.

For solanaceous and cucurbit crops, the following significant industry components were identified: land, water, capital, cultivars, insect control, disease control, weed control, culture and management, mechanization of production, post-harvest handling, waste management, transportation, marketing, cost of production, and public policies. As noted above, the number and definition of components is peculiar to the particular industry being analyzed. Typically, the first two or three pages of the worksheet preceding the tabular presentation for each component is devoted to a narrative summary of the current status and potential of the industry.

In the worksheet, for each industry component all pertinent factual information is concisely presented in the form of narrative statements at the top of the page (see Exhibit 1). In the tabular format occupying the lower part of the page, space is allocated for entering information on priority, bottleneck, action required, agency responsible, possibility of success, duration, resources, and impact if the bottleneck is not eliminated. Since the worksheet represents the first step in the analysis, many of the items included in the tabular format headings are not addressed; that is, the spaces are not filled in at this stage of the analysis process. The items usually addressed in the worksheet are: description of bottleneck, action required, the agencies believed to be best able to assume responsibility, and the probable impact (last column) if the bottleneck is not eliminated. The items not typically addressed at this stage are those dealing with: possibility of success (of a required action), duration (expected time required to execute an action), and resources (required, allocated, supplement source).

b. Industry Meeting

After the analysis group has completed that it considers to be a satisfactory worksheet, the CTAHR sends out invitations for a day-long meeting to all known members of the industry, including farm operators, cooperatives and associations, and relevant government agencies. Members of the analysis group also attend.

The purpose of the day-long session or "town meeting" is to reach a consensus agreement on the commodity industry's potential and on the bottlenecks which prevent it from achieving its potential. Probably the most important function of the town meeting is to get the industry members to rank the bottlenecks in terms of priority order. That is, each bottleneck is assigned a numerical priority from 1 (highest priority) through 20 (lowest priority) or however many bottlenecks there are. Consensus on priority ordering is

EXHIBIT 1

Reproduction of Work Sheet For Solanaceous and Cucurbit Crops

VI. DISEASE CONTROL

Analysis

1. Available lands have been cropped several times each year and this practice favors the build-up of phytopathogens within the crop areas. Hawaii's moist, warm tropical environmental conditions also contribute to disease problems. These conditions favor the multiplication, dispersion, and infection of several disease organisms.
2. The presence of alternate weed hosts in adjacent non-crop areas serve as virus and aphid reservoirs throughout the year and probably accounts for the prevalence of virus diseases in several vegetable crops. Several virus-vector diseases cause severe losses in the field which include cucumber mosaic, watermelon mosaic, spotted wilt, potato Y virus, and tobacco mosaic virus.
3. The major diseases of tomato are: bacterial canker, bacterial spot, bacterial wilt, pythium, rhizoctonia, sclerotinia, southern sclerotium wilt, spotted wilt, and tobacco mosaic virus.

(continued on page 11a)

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources Required	Resources Allocated	Resources Supplement Source	Impact if bottleneck not eliminated
	Lack of implementation of proper disease control strategies.	1. Implementation of proper disease control strategies (crop removal, sanitation, weed control)	Industry CTAHR						The industry now loses about ___% of its crop to diseases. If proper disease control strategies are implemented, the industry will be able to reduce the losses caused by diseases.
		2. Determine effectiveness of chemicals currently used.	CTAHR						
		3. Develop manual on disease control.	CTAHR	Good		More funding necessary for Publications Office.			
		4. Develop integrated pest management control measures for all diseases.	CTAHR	Good		$20,000			

achieved by means of a voting procedure. Industry participants first decide (by vote, if necessary) to group bottlenecks into high, medium, and low categories, then industry members vote on the relative priority ranking of each bottleneck within each of the three groups until the ordering for the entire group is established. Only members of the industry participate in the voting to set priorities.

During the course of the discussions that take place at the town meeting, changes in the worksheet may be made based on new information introduced by industry members or disagreements over the significance or definition of industry components and the action required to remove bottlenecks. Sometimes new bottlenecks are identified and others are discarded. The ultimate purpose of the entire process is to produce an analysis and action sheet which represents the industry's own assessment of its potential and of the order of importance of the bottlenecks which stand in the way of its growth.

c. Analysis and Action Sheet

With the results of the priority setting and the associated input of industry members and others at the town meeting, the analysis group prepares the industry analysis and action sheet. The former is a report in narrative form which begins with a one page preface that explains the purpose of the industry analysis, the fact that it was prepared in a joint industry-government effort but represents the views of the industry, and how the analysis is structured. All persons who contributed to the analysis are also identified in the preface. Following the preface, a concise assessment of the current status, and potential of the industry is given. The next section, which is the major product of the report, is the analysis of each component of the industry. For each component, the state of knowledge of the component is presented first, then the identified bottlenecks are discussed. For each bottleneck, the industry-determined priority is given, together with the impact if the bottleneck is (or is not) removed, and the actions required to eliminate the bottleneck.

The action sheet is in exactly the same format as the worksheet, except that the columns dealing with possibility of success, duration, and resources are now completed for many (but not all) of the bottlenecks and corresponding actions required. Exhibit 2 depicts page 4 of the action sheet for the macadamia nut industry. In contrast to the worksheet, the material appearing in the action sheet represents an updated and more refined analysis. Also, the material in the action sheet is further elaborated in the analysis report with respect to the columns on "bottleneck" and "action required." The information supplied in the columns on "possibility of success," "duration," and "resources" is important and unique to the action sheet; that is, this information only appears in the action sheet (if available at all) and is not contained in the narrative analysis report.

3. Results of the Industry Analysis

The completed analysis report and action sheet are given to industry spokesmen. If they are satisfied that the analysis and action sheet accurately present the potential, priorities, and action required to eliminate identified bottlenecks, they then designate a single industry representative to present the analysis results to the Governor's Agriculture Coordinating Committee (GACC).

After the industry analysis results are presented to the GACC, there is typically a period of about one month in which the member agencies of the GACC review the analysis. After this review, another GACC meeting is held for the purpose of presenting the State response. The GACC may request revisions in analysis sections in which factual information is questioned, or it may disagree with priorities or on the kinds of actions which have been recommended

EXHIBIT 2

Reproduction of Action Sheet For
Macadamia Nuts

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources: Required	Resources: Allocated	Resources: Supplement Source	Impact if bottleneck not eliminated
3	Lack of processing technology to increase the kernel recovery rate.	1. Develop improved processing technology using new principles to increase kernel recovery rate.	CTAHR	For the completion of the new roller-type cracker					If the technology to increase the kernel recovery rate can be developed, the profitability of the industry will increase.
				Good	1-2 yrs.	Available resources are adequate.			
				For work on other new processing technology, some basic research needs to be done.					
				Good	3-5 yrs.	$10,000/yr. for a Grad Res. Asst. and operations	None	$10,000/yr. from the GACC	
			Industry						
		2. Evaluate the quality and shelf-life of kernels processed by the system utilized by the Kona-Hawaiian Macadamia Co. Also make objective measure of the changes which affect shelf-life and quality. (Quality and shelf-life are two separate problems.)	CTAHR	Good	1 yr.	Available resources are adequate.			
			Industry						
		3. Design improved large processing systems. Determine the quality and shelf-life of kernels processed by the system.	CTAHR	Good	1-2 yrs.	Available resources are adequate.			
			Industry						

by the industry. Of primary importance, however, is the GACC's response in terms of the actions it agrees to undertake in support of the industry. Typically, only certain actions involving the highest priority bottlenecks can be addressed within the GACC's budgeted resources. Therefore, any particular industry will usually obtain a relatively modest amount in terms of direct funding support. However, the industry analysis, in the form accepted by the GACC, is to be used as a guide for all state agencies insofar as the design and operation of projects and programs affect the industry in question.

4. Use of the Industry Analysis Program in Planning and Resource Allocation

To undertake useful planning, relevant information must be available or capable of being obtained at reasonable cost. Agricultural planning requires not only aggregative information of production, yields, prices, etc., but also qualitative and quantitative data on the full range of operational and business environmental conditions within which production occurs. This latter kind of data includes technical factors such as the incidence of pests and diseases affecting crops and livestock, soil nutrient and erosion conditions, and efficient harvesting and production equipment; institutional factors, such as land use controls and tenure, water rights, and availability of training and extension services; and economic factors, such as availability of production inputs, transportation of output to markets, capital and credit, and reasonably efficient marketing channels for farm products.

The industry analysis program provides an important source of information for the identification and analysis of the problems which affect farm operations within a particular commodity or resource area. As such, this auguments information obtained by Cooperative Extension agents, and the statistical programs in agriculture (The Hawaii Agricultural Reporting Service, a cooperative federal-state program housed in the State Department of Agriculture), which have heretofore provided most of the primary data used for planning and administration.

The information generated by the industry analysis program is essentially micro, farm and industry level, information. Extension agents also gather micro level information, but individual agents tend to focus on specific farm operator problems which are typically technical in nature. The analysis process represents a concerted effort on the part of many individuals to identify all significant problems. The number of industry participants and wide range of expertise of government and other researchers and policymakers focusing on the industry, tends to produce a large amount of information that would not otherwise be obtained by relying only on existing extension service and statistical reporting programs.

As previously mentioned, the industry analysis program is at an early stage of development, and there is certainly room for improving both the quality and extent of coverage. However, the information contained in the eighteen industry analyses completed up to July 1981, represented a significant component of the overall data base used in formulating the State Agriculture Plan published in September, 1981.

In terms of resource allocation, it is clear that the industry analysis program can affect funding decision making, but precisely how and to what extent is not clear. After a completed industry analysis is accepted by the GACC, typically some funds from the GACC budget are allocated to the industry for high priority bottlenecks. Usually, funds are allotted only for actions which are considered to be of an innovative, demonstration, experimental, or emergency nature. Also, these allocations are usually for one-time projects, rather than ongoing programs and for actions for which no other private, county or federal monies are available. The GACC's funding decisions are based on the relative importance of the industry and the particular bottleneck which is being considered. However, no formal, objective criteria currently are being used by the GACC itself to set priorities among industries.

One of the principal duties of the GACC is to coordinate and review the preparation and submission of all departmental budgets as they relate to agriculture (Chapter 164, HRS). With this authority, the GACC is in a position to utilize the industry analyses to affect the allocation of state resources to the various commodity and resource industries. Results of this decision-making process are reflected in the executive budget which is sent to the Legislature biennually (a supplemental budget goes to the Legislature in the interval years); exactly how the industry analyses accepted by the GACC are used in formulating the departmental budgets in relation to agriculture items is not known. The State Plan Act provides that once the Legislature adopts the functional plans, the State's program appropriation and capital improvements program process shall be in conformance with those plans. However, a mechanism is needed for translating the priorities and actions contained in the individual industry analyses to an overall agricultural budget which crosses departmental lines. This need is alluded to in the State Agriculture Plan (see Section IIIB), where it is stated that upon adoption of the Functional Plan, the DOA would develop an Action Program of Work Plans, Budget and Priorities, which would be submitted to the GACC.

Formulation of the industry analysis process has been largely at the initiative of CTAHR, which is also the major agricultural research agency of the State. As indicated, results of this process can provide or augment the information base required for resource allocation decisions. They may also indicate a consensus on priority problems and remedial actions to enable an identified industry to reach its potential. The possibilities of expanding, modifying, or adapting this process to meet the broader needs of a State agricultural planning process or perhaps the more fundamental requirements for agricultural development in the other Pacific islands will be considered subsequently in this report.

E. Some Guidelines for Research Priority Setting

From this review of resource allocation models, some guidelines for establishing a research priority setting process may be derived.

Given the inherent difficulties in undertaking public agricultural research, the conventional B/C analysis approach may not be feasible. Research management still must be concerned with evaluating the relative benefits versus costs for research alternatives, but the appropriate framework must explicitly recognize the problems of defining and measuring benefits, the critical role of social, as well as biological and physical scientists in the evaluation process, the fact that research benefits must be evaluated in terms of their contributions to specified goals, and that they must be widely disseminated to include all social sectors. While the benefits and costs of investment in public agricultural research are appropriately measured in terms of their contribution to society's goals, at the same time applied research and the generation of new technology must consider the needs and objectives of both small and large-scale farmers, comprising the agriculture sector. New or improved technology must be accepted or adopted if the benefits of the research program are to be realized.

Resources committed to research management (i.e., evaluation or research alternatives and the selection of projects expected to produce maximum benefits consistent with budget resources), must be commensurate with expected benefits, as is the case for any research alternative. Thus, the sophistication of the research priority-setting process will definitely be constrained by the overall size of the research program itself. Moreover, an overly demanding system in terms of scientists time is likely to be counter-productive.

The essential elements of an efficient and effective agricultural priority-setting process would include the following:

(1) Given the broad social goals of the country (or state), there must be a consistent corresponding set of goals for the agricultural sector. Sector goals should be specific. While higher level goal setting is essentially a political process, the more specific the goals, the greater the need for a rigorous examination of the environmental, social, economic and political conditions which determine their choice and of the needs and concerns of the farmer and other clientele groups affected by the process.

(2) There should be a systematic process for translating sectoral goals to scientists' working objectives. The process must involve the scientists, but must not be too burdensome. At the same time, it must involve clientele groups, but not be too cumbersome. This translation process not only generates the range of research alternative, but constitutes the basis for their evaluation.

(3) The translation process should begin from an holistic perspective, but will necessarily involve dividing the program into sub-areas of research

focus, typically commodities, resources, or organizations/systems (e.g., farming systems, farm management research, agri-business).

(4) The translation process also will entail the systematic collection and analysis of information. Three basic kinds of information are needed: market data, farm level data, and research data. Market data refer to both commodity demand and the demand for inputs. Local and export markets are of concern, as well as information on supply and demand elasticities. Farm level information includes data on production, productivity, and production risk. Social and economic, as well as natural environmental conditions influencing production, also must be known. Research data refer to estimates of time, cost, and probability of success, once researchable problems and alternative technologies have been identified. This information should contribute to problem identification and research planning in an iterative and dynamic feedback process.

(5) The size of agriculture and the corresponding research program for many states will not warrant the resources necessary to construct large scale simulation or other kinds of quantitative models for the purpose of evaluating benefits of research alternatives. Therefore, the evaluation of expected contributions to sectoral goals of the research alternatives must be handled in another manner. Conceptual, non-quantitative models, indicating key actors and linkages and principal directions of progress or feedback, may be developed. Basic to use of either quantitative or non-quantitative models is establishment and agreement on a set of evaluation criteria. Evaluation criteria would be derived from the underlying social, economic, and natural resource conditions of the country. Criteria should be consistent with

higher level goals, and expected benefits should be capable of being measured in terms of the criteria. For example, these criteria might include contribution to increased farm employment, commodity export earnings, increase in small farm income, or increase in share of domestic market for selected commodities.

(6) Once specified, the evaluation criteria provide guidance in devising basic research strategies and identifying relevant researchable problems and potential alternative technologies for solving them. Application of the criteria would entail two steps. First, scientists would need to estimate the impacts of each alternative in terms of technical efficiency, commodity characteristics, or production risk; and secondly, the estimated impacts need to be assessed in terms of the criteria. Although the use of evaluation criteria involves the problem of weighting, this can be dealt with through the use of reliable quantitative data augmented by expert judgement or through a more systematic qualitative consideration.

The above elements of an effective priority-setting process will be illustrated and evaluated in terms of the Hawaii agricultural research program in the following section.

III. RESEARCH PRIORITIES AND AGRICULTURAL DEVELOPMENT PLANNING IN HAWAII

Agricultural planning, like sectoral planning for transportation, housing, and other areas, must be related to overall state goals and objectives. State government in Hawaii recently enacted into a law a State Plan and a related planning process. The statute specifies State goals, objectives, policies, and priorities and establishes a structural and operational mechanism for their implementation. The law also calls for the preparation of functional plans in twelve subject areas which are intended to detail specific objectives, policies and implementing actions in support of overall State goals. The State Agricultural Plan is one of the twelve functional areas addressed by the State Plan.

State agricultural planning requires the setting of sectoral goals and objectives which are to guide resource allocation. Resources thus committed are expected to affect agricultural activity in such a way that contributions are made to more general state goals in an efficient manner. Research and development is an important component of the overall agricultural development process, and therefore research resources should be allocated so that expected benefits result in maximum contribution to sectoral goals.

A. Limitations of Present Resource Allocation Process

Most, but not all, publicly-funded agricultural research in Hawaii is administered by CTAHR, and encompasses the entire spectrum of basic to applied research. The IAP which was developed for the Governor's Agricultural Coordinating Committee (GACC) and is administered by CTAHR, addresses the problem of setting priorities for the allocation of resources to solve identified industry problems.

Applied research may be necessary for the resolution of many agricultural industry problems; however, the IAP is broader in that all problems of an industry are considered, not just problems requiring research. For example, lack of physical infrastructure, government regulations, and transportation services may be problem areas. In some cases, the problem may be quite apparent, and research is not needed to obtain a solution. However, if research and development is construed in a broad context, a very large proportion of the problems, restraints, and opportunities in agriculture require some amount of research effort before action can be taken. Considered in this broader manner, the IAP is a mechanism for setting priorities for the allocation of resources to applied agricultural research.

A number of significant limitations and problems prevent the IAP from realizing its full potential as an efficient priority-setting mechanism or process. These are discussed in the following sections.

1. Priority-Setting

The commodity industry analysis currently results in the identification of problems or bottlenecks which are prioritized by members of the industry. Industry problems are assigned priorities in ordinal rank order through a voting procedure. Each industry member present at the IAP meeting casts his "vote" for the priority of a given problem based on his personal assessment of the information presented in the Analysis Worksheet, including any modifications of the analysis made during the course of the meeting. Therefore, while priorities among problems are determined at the individual industry level, there is currently no formal means of setting priorities for problems among industries. For example, there is no basis for concluding that a problem ranked number 10 in the sugar industry is more important (ranked higher) than a problem ranked number 11 in the macadamia nut industry.

Since research projects are regularly funded, decisions on relative importance are obviously made by CTAHR and other agencies conducting research on agricultural problems. As previously discussed, the GACC has limited funds for research on problems of special importance. These funds are presumably allocated among industries on the basis of their relative importance, but no formal criteria are used to determine relative importance.

The State Agriculture Plan notes the lack of priorities and recommends that the state, "set priorities for assisting agricultural industries according to criteria, including but not limited to export sales potential, import substitution potential, economic significance of industry, and feasibility and cost-effectiveness of public support."

2. Organization, Resources and Analysis

The IAP is conducted on an informal basis; formal procedures for organizing and executing an industry analysis do not exist. While the program was initiated, and has evolved, in response to a need identified by the Legislature and GACC, it is not a formal program within the CTAHR, and funding is not specifically budgeted for the IAP on a regular, ongoing basis.

Given the informal nature of the IAP, there are no guidelines for participation. Since the CTAHR administers the program, the burden of producing the written analytical documents (Worksheet, Analysis and Action Sheet) is placed on faculty and staff within the CTAHR; participation is sought from industry and government agency personnel, but varies according to resources and current interests of the agencies.

Without specific funding and formal program status, the scope of effort and depth of analysis is necessarily constrained. The analysis of a given industry frequently takes a year or more to complete, and as a result some commodity industries have not been analyzed. It takes two to three years before an industry is analyzed on an updated basis, and to date, only one resource area (agroforestry, forests and natural resources) has been analyzed.

Although the analysis is supposed to represent the position of the industry, given the limited participation of industry persons in the analysis per se, and the technical nature of many of the problems addressed, the analytical process must rely heavily upon the efforts of the CTAHR and other government professional and technical personnel. Undoubtedly a reflection of the limited time and resources available, most of the analyses do not address industry potentials in a comprehensive or in-depth manner. While biological and technical problems relating to production, harvesting, and processing are covered in some depth, problems relating to marketing, export potential, factors of production, distribution, transportation, extension, and infrastructure are less adequately treated, even though they are frequently ranked highest in priority. Moreover, there is little analysis of the impact on the industry if a bottleneck (problem) is not eliminated.

3. Goals and Objectives

Under the present ground rules, the IAP is not concerned with state goals with respect to the setting of priorities within a given commodity industry. However, the GACC, CTAHR and other state agencies must be concerned with the expected contributions to state goals from projects that are funded.

The expected benefits of publicly-funded projects in support of agricultural research, as well as other projects, should be evaluated in terms of the developmental objectives established by the functional planning process. With respect to the present State Agriculture Plan, the specification of objectives is not adequate. That is, the objectives as stated do not provide a suitable basis for project planning, nor the ex ante evaluation of expected benefits.

While the Plan's objectives (State Agriculture Plan, September 1981, p. I-6) focus on the principal agricultural resources: land, water, capital, labor, and transportation, a more specific set of sectoral objectives is needed to guide development and the planning and evaluation of research. For example, the land objective, "achievement of productive agricultural use of lands most suitable and needed for agriculture," is not very useful for project planning.

To be useful, objectives should be expressed in terms which permit the establishment of benchmarks and measures of progress. That is, one should be able to indicate what the current situation is by means of objective criteria, and be able to determine the extent of change through time with reference to the same criteria. Typically, measurable end state or planning targets should be specified. Ultimate society goals may be broad or generally worded, but sectoral (lower level) goals should not only be internally consistent, but defined in terms which facilitate the determination of progress in achieving the ultimate goal(s).

4. Public Versus Private Priorities

As previously mentioned, the setting of priorities or ranking of problems within an industry in the IAP is by means of voting on the part of industry participants. While the GACC is not bound to abide by the priority rankings, once it accepts the analysis there would seem to be an implicit obligation to recognize the priorities to the extent that state resources are in fact committed to projects and programs directly affecting the industry. While it is important that industry needs and objectives be considered and participation in the design of projects and programs obtained, at the same time, the interests of elements not typically represented in the process, as well as larger public interest must be observed. This can only be done if the priority setting process is responsive to well-defined and widely accepted sectoral goals.

5. Participation

Successful applied research and development results in new technology which is adopted by farmers and others in the agricultural sector. New technology provides benefits to many, but may result in adverse environmental, economic and social effects for other segments of the population.

Within agriculture and specific commodity industries, the characteristics of farm operators, processors, distributors, suppliers, and providers of services are very diverse. Differences in farm size, form of organization, location, education, social and demographic attributes, access to capital, and other matters are prevalent. Broad participation in the IAP process is necessary to ensure that significant problems will not be overlooked and all relevant factors will be affected.

Presently, no formal guidelines exist in regard to participation in an industry or resource analysis. Participation is by invitation or by word-of-mouth, both in terms of contribution to the preparation of the analytical documents, and general participation in CTAHR-sponsored meetings with the industry. The CTAHR maintains a list of industry members and mails invitations to the meetings which it sponsors; selected persons in government agencies who are knowledgeable or have an interest in the industry are also invited to attend meetings. Consumer and environmental groups, and other organizations which may be affected by a given industry, are typically unaware of the IAP.

6. Program Scope

Twenty-five agriculture commodity industries and one resource have been defined and comprise the IAP to date. Thus far almost all program effort has gone into analyzing commodity industries. Input resources such as water, labor, and land have not been addressed, nor have areas such as human nutrition, farm management, farming systems, agri-business operations, and specific areas within human resources.

Although land, labor and water have been addressed within each commodity industry, the frequency of problems related to given factors of production may warrant a cross-commodity research approach. In turn, a multidisciplinary approach focused on a given resource could result in deeper comprehension of industry problems. Findings could be utilized in the individual commodity analysis with necessary modifications to take into account special conditions.

Another significant problem related to program scope involves the discovery and consideration of new and potential commodity industries. Currently, commodity industries must have some minimal degree of organization before an analysis is considered. However, research and development needs may be quite large at the outset--particularly with respect to assessing the potential of commodities which are not yet in commerical production. Some of the new aquaculture enterprises, such as oysters, marine shrimp, and tilapia are cases in point.

7. Budgeting Considerations

For each problem identified in the commodity industry analysis, associated actions to resolve the problem are specified along with an estimate of resources required. While budget estimates are made for most of the actions for which CTAHR is responsible, those actions to be implemented by other agencies frequently do not indicate budget requirements. In many instances, it is noted that adequate resources are available to carry out the action, but the dollar amount and personnel needs are not indicated.

Even if only the top five ranking priorities are considered in terms of each analysis accepted by the GACC, the total amount of funding requested from the GACC would exceed the amount of funding available. Typically the GACC allocates a limited amount of funding to each industry for a high priority problem area subsequent to the acceptance of the completed industry analysis. Aside from these actions by the GACC, it is not clear how the various analyses affect the state agency budgetary process.

The accepted industry analyses are supposed to guide agency resource allocation decision-making, but the manner in which they do so is not apparent and not reflected in the State Agriculture Plan. For example, how much is allocated per annum to address the problems of each industry? What progress has been made on the basis of resources committed? What are the unmet resource needs for given industries and problems? These are some of the obvious questions, answers to which are needed for effective planning and program evaluation.

B. Requirements of State Agricultural Planning

1. Background

Enactment of the Hawaii State Plan, Act 100 of the 1978 Legislature, established the basis for the State Agriculture Plan, which is one of a dozen functional plans formulated to detail and implement the overall State Plan. In addition to the agriculture plan, functional plans have been completed for energy; transportation; water resources development; historic preservation; recreation; health; conservation lands; education; housing; higher education; and tourism.

Based on extensive public participation through public opinion polling, information meetings and public hearings, the State Plan includes an overall statement of values, goals and policies which are to guide the long-term development of Hawaii. The State Plan also contains a set of priority directions and a designated implementation process. The priority directions cover statewide, interrelated problems and issues which are of immediate legislative concern and are intended to give guidance to the state agencies and counties in developing their plans. County general plans and State functional plans (which may be passed by legislative resolution) are to be consistent with the current set of priority directions. The implementation process involves a Policy Council (comprised of State, County and public representatives), the State Department of Planning and Economic Development (DPED) as the key planning and coordinating agency, the State functional plans, the County general plans, the State programming and budgetary process, and the State Legislature. The interrelationships among these basic elements of the implementation process will become apparent as the agriculture functional plan is discussed.

Legal enactment of the State Plan and its accompanying planning process may be considered a further milestone in the evolution of public planning in Hawaii. Among the fifty states, Hawaii was the first to initiate a comprehensive statewide planning process. The first notable products of this process appeared in 1961 with the nation's first state land use law and a state general plan, which was approved in principle but not adopted into law.

The State Department of Planning and Economic Development was established in 1963 to carry out the planning process which involves enunciation of citizen goals, assessment of the State's economic resource base and alternative courses of future action, utilization of the land use law and long-range capital and program budgeting to meet State objectives. This process enabled public action in Hawaii to keep pace with the accelerated development which occurred in the 1960s and early '70s with the onset of Statehood, jet aircraft, mass tourism, international investment interest, and continued population growth. During this period, it was also becoming evident that this rapid growth was placing additional pressures on the State's limited land and environmental resources and that costs of accelerated development had begun to catch up with or exceed benefits. A State Growth Policies Plan was issued in 1974, calling for measures to slow down overly rapid development, conserve and protect environmental resources (including the State's best agricultural lands), and ensure that future growth would meet the needs and be within the capacities of state residents. These actions and developments were to provide the basis for the State Plan enacted in 1978.

2. State Agriculture Plan

The purpose of the Plan is to facilitate achievement of the two fundamental objectives of the State Plan, that is: (1) increased viability in sugar and pineapple industries, and (2) continued growth and development of diversified agriculture throughout the State. The Hawaii State Plan lists specific policies and priority directions which relate to agriculture (Part I, Section 7, and Part III, Section 103), and which are to be addressed by the agriculture functional plan. The functional plan defines policies as long-range courses of action to be carried out in order to achieve related objectives; priority directions are to provide the focus for public and private actions to address major statewide problems which require more immediate attention. The Agriculture Plan is also responsive to certain broad goals contained in the State Plan; these relate to a strong, viable economy, a desired physical environment, and physical, social, and economic well-being. Emphasis is placed on the goal of a strong, viable economy.

In detailing how the objectives, policies, and priority directions of the State Plan are to be implemented, the Agriculture Plan emphasizes the delivery of services and the allocation of resources by State agencies. Also covered in the Plan is the relationship and coordination of agricultural policies and actions with those of other State and County plans. The agriculture functional plan along with the other functional plans are intended to guide such State programs and activities as the following:

(a) The program appropriations process for the biennial and supplemental executive budegts.

(b) The capital improvement project appropriations process.

(c) The budgetary review process of the Department of Budget and Finance.

(d) The land use decision-making processes of the State Land Use Commission and the Board of Land and Natural Resources.

(e) The A-95 State Clearinghouse process.

The objectives, policies, and implementing actions of the State Agriculture Plan are concisely stated and follow a format which first presents the objective followed by the corresponding policies. Under each policy are listed recommended implementing actions. For each implementing action, there is indicated the implementing organizations, assisting organizations, timeframe for the action, and comment. If budget information is applicable and available, it is provided in the comment. The Plan itself includes only the preferred implementing actions which are considered to be of the highest priority. Alternative implementing actions and lower priority actions are presented in the Technical Reference Document.

Seven objectives are included in the Plan. They are as follows:

A. Achievement of Maximum Public Benefit from Allocation of Resources to Assist Agriculture.

B. Achievement of Productive Agricultural Use of Lands Most Suitable and Needed for Agriculture.

C. Achievement of Efficient and Equitable Provision of Adequate Water for Agricultural Use.

D. Achievement of Adequate Capital, and Knowledge of its Proper Management, for Agricultural Development.

E. Achievement of Adequate Supply of Properly Trained Labor for Agricultural Needs.

F. Achievement of Adequate Transportation Services and Facilities Economically Feasible Rates to Meet Agricultural Needs.

G. Achievement of Optimal Contribution by Agriculture to the State's Energy Needs.

Of the seven objectives addressed in the Plan, five deal with factors of production--land, water, capital, labor, and transportation. Objective G relates to an area of special concern--the provision of renewable sources of fuel for energy. Objective A is quite broad in that it relates to all potential uses of public resources to assist agriculture, qualified by the proviso that such uses result in maximum public benefit. In reality, Objective A may be considered a residual category for all implementing actions not addressed in the specific areas dealt with in Objectives B through G.

In the Plan, Objective A covers a broad range of problem areas categorized as government support concerns. Four policies in regard to government support are stated as follows:

A(1). Encourage and support pest and disease controls to increase agricultural production and economic growth.

A(2). Encourage the development of agricultural cooperatives and

and associations and promote effective marketing of agricultural commodities.

A(3). Utilize the agricultural industry analyses as a guide in allocating resources to assist agricultural commodity industries.

A(4). Establish a system for the comprehensive assessment of Hawaiian agriculture and the optimal allocation of public resources to assist agriculture.

Of the eight very high or high priority implementing actions, four relate to policies A(3) and A(4) regarding the use of the commodity industry analysis as a guide to resource allocation, and establishing a comprehensive system for assessing agriculture. The four implementing actions recommend: (1) completing industry analyses for all agricultural commodities, (2) set priorities for assisting agricultural industries according to specific criteria, (3) augmenting the existing information gathering and analysis program, and (4) provide for ongoing implementation, review, and updating of the State Agriculture Plan.

The Plan does not address the problems or needs of commodity industries, such as sugar, beef, or papaya in regard to Objective A concerns or in terms of any of the other Plan objectives. It is clear, however, that the dominant source of information used to analyze the problems of agriculture is the industry analyses completed by CTAHR. The Plan notes (p. II-75) that the industry analyses are considered to be the best available means for identifying specific industry problems and needed actions. At the time the Plan was being prepared, eighteen industry analyses had been completed. These analyses were used to identify those problems which were common to a number of industries--problems relative to land, water, capital, labor, and transportation, for example. Table 1 and Figure 2 are taken from the Plan and list the commodity industries analyzed and the priority problems in each industry, respectively.

Plan policies and implementing actions are not couched in terms of specific commodity industries, as mentioned before, but relate to the overall agricultural sector. Although not covering particular industries or geographic areas, material in the Technical Reference Document addresses specific problem areas (other than land, water, capital, labor, and transportation) common to many of the commodity industries. Farm management, cultural practices, livestock production, waste management, government regulation, pest and disease control, handling and processing, and marketing are discussed in a concise summary manner (p. II-78 through p. II-85, Technical Reference Document). Source of the information and analysis was the industry analyses.

An area of particular concern in the Plan is the need for a more effective public resource allocation system. This problem area is noted a number of times in the Technical Reference Document in relation to augmenting the present statistical and market information systems, expanding the present industry analysis program, and the need "... to provide timely and regularly updated information on the status of government appropriations, allocations, and expenditures in support of agriculture both in terms of specific problem-oriented actions (such as assistance to industries) as well as agency programs in the broader areas of land, water, capital, labor, and transportation." (p. II-87 to p. II-89, Technical Reference Document).

3. Agricultural Planning Process

The process of preparing the agriculture plan and its subsequent implementation involves a large number of state government agencies, the university, federal and county agencies, and industries comprising the agriculture sector.

Figure 2

Problem Areas Identified by Industry Analyses

INDUSTRY	Land	Water	Capital	Labor	Transportation	Farm Management	Cultural Practices	(a) Cultivars	(b) Culture & Management	(c) Harvesting	Livestock Production	Waste Management	Gov't Regulation	Pest & Disease Control	(a) Insects & Parasites	(b) Diseases & Nematodes	(c) Weeds	(d) Rodents & Birds	Handling & Processing	Marketing
Anthurium	18	20	22		5			1	6,11 12,15 16,17				9		4	3	7		2	8,10 13
Banana	1,13				10	8		7	3						6,11	5	12		2	4,9
Beef. & Pasture	1	1	7	15	3	16					4,8 10,11	14	5,12		6	6,9			2	2
Dairy	4	5	7	15	13	6					1,2,8 13,14	10			12	9			3	3,11
Dendrobium	14	15	4					2	7,8,12 13						6	5,9	16			1,3, 10,11
Guava	11	11		12	4	5		13	6				2		9	7	10		3,8	1,14
Leafy Vegetables	10	2,11	20		15	14		6	7,9,12 19	22		13			3	4	16		1,17	5,18 21
Macadamia Nuts	15	8				22		12	6,9,13 17,21	10			11,16		19	5,18	20	7	3,4	1,2
Ornamental Potted Plants	2	11,21	6	15	5,7	4		16	12,14					19	10	1,20			9,17	3,8 13,18
Papaya				9	2	16,18		11,14	14,17	20			22		1,21	3,5 10,12	6		8,15 19	4,7 13
Passion Fruit	low	low						6	1,4						5	2,low	3			
Pineapple	11	16,17		18,19	13				12,15 21,24			8,14 22,23			2,10 20	1,3,4 5,6,9			7	
Poultry & Eggs	2	17	7	16		4					1,6,9 11,12 13	5	15		8	8,10				3,14
Protea	12	10	2	17	15	13		6	11				8		5	4,7	14,16		3,9	1
Sugar		5		19		17,18		3	10,11 15,20 22	16		4	2		9	8	13	7	12,14 21	1, low
Taro	2	1		8	3,6	11		9	7,13 14,17			18		16	5,15	10	12			

Note: Number one (1) indicates highest priority problem area, number two (2) second highest priority, etc.

Source: Reproduction of p. II-77, State Agriculture Plan, September 1981.

This section attempts to describe the Hawaii agricultural planning process with an emphasis placed on how objectives are to be achieved.

The lead agency in agricultural planning is the State Department of Agriculture (DOA). Coordination of agricultural policy, review, and monitoring of specific agricultural programs and projects are undertaken by a Governor's Agriculture Coordinating Committee (GACC). While both the DOA and the GACC have thus far shared in administering the agricultural planning process, the State Plan Policy Council has recommended to the Legislature that full responsibility and accountability for overseeing the Plan and monitoring its progress toward implementation rest with the DOA (DPED, December 16, 1980).

The GACC is comprised of the director of DPED, the chairperson of the Board of Land and Natural Resources, the chairperson of the Hawaiian Homes Commission, the dean of CTAHR, three farmers, one of whom shall represent a nonprofit association of farmers, and the GACC chairperson, who is the special assistant for agriculture in the office of the Governor.

The GACC is responsible for preparing a state agricultural policy which is submitted to the governor for approval; the coordination of all state agricultural activities as they relate to the federal and county governments, public and private organizations, and commercial enterprises. In addition, it has responsibility for the coordination and review of (1) agricultural and agriculture-related programs and projects of all state agencies for submittal to the governor, (2) all departmental budgets as they relate to agriculture, and (3) activities of all departments to ensure timely and efficient implementation of authorized agricultural and agriculture-related programs.

The starting point in the process is the formulation of an overall agricultural policy by the GACC, consistent with the State Plan's theme, goals, agricultural objectives and policies, and priority directions. Within this overall context, the DOA prepares the State Agriculture Plan. In preparing the Agriculture Plan, the DOA must interact and coordinate with the CTAHR and the other state agencies which are preparing similar state functional plans. It is obvious that such functional plans as those for housing, water resources, transportation and energy will affect, and be affected by, the agriculture plan. The other functional plans, too, will contain objectives and policies which will affect agriculture in varying degrees.

The CTAHR, in carrying out its education, research, and extension functions, must be closely involved in providing input to the planning process. As a member agency of the GACC, it is directly involved in formulating policy and in the coordination of agricultural programs and projects. It is through the mechanism of the Industry Analysis Program, however, that CTAHR becomes directly involved in generating basic data and analyses which contribute importantly to the DOA's overall data base and rationale for the agriculture plan. The industry analyses provide information on a specific commodity or resource, which enables planners and policy-makers to judge the relative importance and potential of the industry, the most significant problems or bottlenecks restraining growth, the relative priorities of the actions needed to overcome them, and the corresponding probability of success.

Working in conjunction with the GACC, the DOA must also interact and coordinate with the federal and county governments, each of which has programs, projects, or legal jurisdiction affecting the use of basic resources of importance to the agriculture sector. Relevant federal programs include soil conservation, environmental protection, crop insect and disease control, farm loans, and research and extension. County programs and policies affecting agriculture include land use plans and controls, property taxes, water development and other public facility programs.

In accordance with the State Plan, County general and area development plans are to be consistent with state priority directions and functional plans; likewise, state functional plans are to be consistent with the State Plan's priority directions and the County general and area development plans. Although the previous statement implies some ambiguity as to order of precedence, usual public administration tenets would suggest an ultimate State authority. Nonetheless, once the DOA has drafted the State Agriculture Plan, with the assistance of the Advisory Committee for the Agricultural Functional Plan and the endorsement of the State Board of Agriculture, it must be reviewed by the Policy Council before being submitted to the State Legislature with its recommendations. The Policy Council consists of 18 voting members, including the planning director of each county (4); 9 public members, the director of DPED, who is the Council chairman; and four voting members to be chosen by the governor from among state directors of the following agencies: Agriculture, Budget and Finance, Land and Natural Resources, Health, Social Services and Housing, Transportation, Labor and Industrial Relations, Environmental Quality Control, Education, the University, Housing Authority, and Land Use Commission. Those state agency heads not chosen as voting members remain on the council as non-voting members.

The Policy Council's primary duties are to ensure that the state functional plans are prepared in accordance with the State Plan and legislative directions, and that any conflicts among the functional plans (and between functional plans and county plans) are resolved.

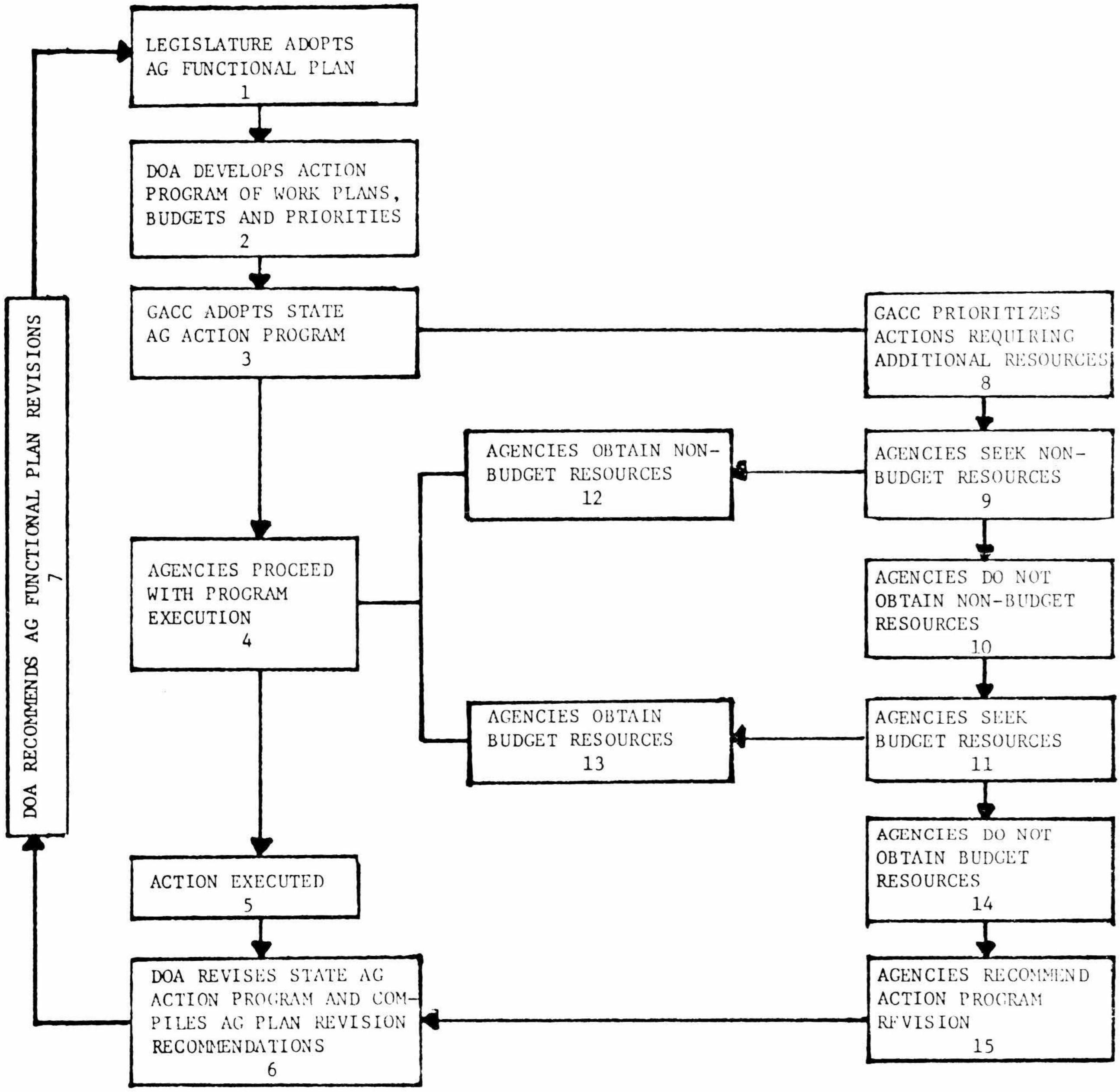
Implementation of the Plan and other state functional plans proceeds with their adoption into law by the Legislature. Since the State Plan specifies that the functional plans may not be used as a guide or to implement state policy unless they have been approved by the Legislature, adoption by concurrent legislative resolution is necessary for plan implementation (Section 59(a), Chapter 226, Hawaii Revised Statutes). At the time of this writing, the State Agriculture plan has not yet been adopted by the Legislature, although this is expected to occur during a forthcoming session.

A flow chart showing the implementation process is reproduced from the Plan (see Figure 3). Upon adoption of the Plan by the Legislature (step 1) all State agencies will be required to utilize those provisions of the Plan which apply to their programs and projects. Policy A(3) of the Plan stipulates that the agricultural industry analyses are to be used as a guide in allocating resources to assist agricultural production and marketing. In this example, all State agencies having programs that include farmers or farm organizations in their target or client groups would use the industry analyses to guide resource allocation. However, as noted in the Plan (p. I-18, A(3)(b)), criteria are yet to be adopted for selecting agricultural industry problems for resource allocation.

In step 2, the DOA would work with all other state agencies having programs and projects affecting agriculture and prepare an action program of agency work plans, budgets, and priorities. This action program would then be submitted to the GACC. In the event that industry analyses identify particular problems that cannot be addressed by any agency, then the action program would take note of this.

Figure 3

Action Implementation Process Flow Chart



*Reproduction of Figure 15 in the State Agriculture Functional Plan, p. 208.

In step 3, the GACC reviews the action program, makes adjustments if necessary, and then adopts it. Upon adoption, the GACC submits the action program to the governor for approval of the substantive concept of the program, but not of the budget items per se, which are a part of the action program. In adopting the action program, specific programs and projects will fall into either of two categories: (1) those that already have sufficient resources, and (2) those that will need additional resources to be implemented. Programs and projects in the first category will proceed directly through the steps 4-6 path and those in the second category will proceed to step 8.

At step 4, all State agencies with programs and projects included in the agricultural action program will begin their implementation. The GACC will coordinate the implementation process among the state, county and federal agencies which are involved. The DOA will be responsible for the oversight of program execution to ensure that the State Agricultural Plan is being followed as closely as budgeted resources permit.

Step 5 is self-explanatory, but it should be pointed out that the accomplishment of this step will require different lengths of time depending on the nature of the particular actions being undertaken. In many cases, ongoing programs are being conducted and "action executed" will relate to targeted service levels or other indices of program accomplishment, which, in terms of time, would probably coincide with the budget cycle.

As programs and projects are completed or their objectives accomplished, the action program will be revised by the DOA in step 6. Step 7 represents the initiation of another cycle or iteration in the ongoing agriculture functional planning process. In this step, the DOA will be making recommended changes in the functional plan. Recommended changes will depend on both accomplishments and changes in the total environment within which agriculture operates. Changes in total environment would include such things as large or unanticipated transportation and energy price changes, disruption in supply of agricultural inputs or services, and changes in state economic, social and environmental goals and objectives.

Agriculture programs and projects not having sufficient resources at step 3 are subject to a priority determination process on the part of the GACC in step 8. Regardless of the priority assigned to each program or project, agencies (in step 9) first seek resources from sources (i.e., federal government, private) outside of the State executive budgeting process. If sufficient funding can be obtained (step 12), then program and project actions re-enter the step 4-6 execution sequence. If non-state budget resources are not available, agencies make requests through the regular State executive budgeting process (step 11). If State funds are appropriated and released to the agencies, programs and projects can enter the execution sequence via step 13. However, it should be noted that the time required to go through the executive budgeting process is a minimum of two years. When agencies are unsuccessful in their State budget requests (step 14), they must make recommendations to the DOA concerning alternative courses of action or other appropriate changes to compensate for the lack of resources that had originally been requested (step 15).

It has been noted that the time dimension does not appear in Figure 3's depiction of the agriculture planning process. However, it is apparent that the setting of priorities and the allocation of resources is critical to the amount of time required for achieving planned agricultural objectives. In preparing the Plan, effective communications and working relationships among the principal organizations involved are essential to ensure that requested resources are realistic in terms of planning objectives and priorities. If the action program adopted by the GACC carries a price tag of $40 million, for example, and the Department of Budget and Finance is not willing to fund more than $20 million, then there is obviously a problem. The problem of resource allocation will be further addressed.

Critical elements in the planning process appear to be the formulation and articulation of the Plan's implementing actions, the GACC's setting of priorities for programs and projects needed to achieve the implementing actions, and the process of obtaining resources in line with determined priorities.

C. Integration of State Planning, Socio-Economic Criteria and Agricultural Research Priorities

The IAP has had good political support, as evidenced by its general acceptance by the GACC, and industry support and participation in the priority-setting process has been good. Strengths of the present program are significant and should be recognized--especially in contrast to the situation that existed before the IAP was initiated.

Some of the more significant strengths of the IAP include the following:

(1) Provides an efficient means of two-way communication between farm operators and government officials charged with designing and operating agriculture support programs and projects.

(2) Focuses attention on the respective responsibilities and roles of the various agencies and organizations, and thus facilitates coordination.

(3) Facilitates identification of industry problems and needs, and the relative significance of those needs from the standpoint of the industry.

(4) Directs the attention of planners, researchers and officials to the most relevant factors or variables involved in development planning; e.g., commodity industry potential, factors of production, production technology, prices, and marketing and distribution of output.

(5) Provides motivation for identifying and collecting relevant data, and in doing so draws attention to needed information and data gaps. While the immediate need is to make possible the industry analysis, the information so obtained is also useful for development planning purposes.

(6) Exposes cross-commodity resource constraints and other unmet needs which prevent an agricultural industry from reaching expected potentials and the agricultural sector from a fuller contribution to overall developmental goals.

If the present strengths of the IAP can be maintained, and the limitations discussed above eliminated, the process could well serve the needs of state planning in Hawaii and to a more limited extent the future developmental aspirations of the other Pacific islands. The intent of this section is to propose certain modifications to the IAP which would help overcome some of the current limitations and enable attainment of broader objectives of the state planning process.

1. Specification of Objectives

Prerequisite to setting priorities for applied agricultural research is the establishment of sectoral objectives. In deciding on the allocation of resources among competing research alternatives, efficiency may be attained when expected benefits are maximized for a given outlay of resources; but benefits can only be defined and evaluated in terms of specific objectives. Since specific agricultural objectives at the sectoral level for Hawaii have not been established, a set of suggested objectives will be proposed in this report to illustrate their role in the priority-setting process.

Proposed sectoral objectives for agriculture include the following:

(1) Identify and promote commodities which can successfully compete in the Hawaii market with imports, and obtain increases in market shares.

(2) Obtain a larger contribution to state income from the oversees sales of agricultural commodities.

(3) Realize increasing trends in farm income and employment, placing emphasis on support to small farm operators.

(4) Seek an increase in the growth rate of income from diversified agriculture, giving emphasis to activities in the Neighbor Island counties.

(5) Achieve an increase in state income and employment from agricultural processing and supply industries, and agri-businesses supplying farm services; placing emphasis on new activities, small businesses, and firms selling in overseas markets.

The above set of sectoral goals are responsive to the socio-economic situation in Hawaii and are consistent with objectives and policies set forth in the State Plan. A larger set of more specific objectives could be generated to guide functional planning, relate it to other functional plans, and indicate more particularly how State Plan objectives and policies are being addressed. While in practice this would be desirable, a more refined set of lower level objectives are not needed to illustrate the research priority-setting approach proposed here.

The suggested set of sectoral objectives are specific and indicate desired outcomes of the agricultural development effort. Such terms as State income, commodity market share, farm income, small farm operator, and overseas sales have for the most part already been defined for various purposes, and in most cases corresponding statistics are available to provide benchmark (base year) figures and measures of progress over time. Income measures should always be defined in constant dollar terms.

The first sectoral objective responds to a security concern. While self-sufficiency in food production is a concern, probably very few areas would be willing to pay the price of complete self-sufficiency. Some commodities cannot be produced in Hawaii while others can only be produced at costs far in excess of import costs. However, for many fruits, vegetables, and livestock commodities, domestic producers can supply a significant share of total consumption in competition with out-of-state producers. Publicly-funded agricultural development programs, including research, can increase the competitiveness of many domestic commodities and also can lead to the production of new commodities for the domestic market.

The second sectoral objective recognizes the problem of a limited domestic market. For most given commodities, total consumption requirements can be produced on relatively small acreages. The efficient or profitable scale of operations of the individual producer is typically large relative to total market demand, with the usual consequence being that a number of suboptimal size farm operators supply the small domestic market at commodity price levels which can be effectively met by overseas producers. The limited size of the Hawaii market is primarily a problem for crop producers (rather than livestock producers). For efficient resource utilization, effective demand must be increased. Selling in overseas markets overcomes this problem for commodities that can be produced at relatively low costs in the local environment.

In addition to enabling the productive use of land and other resources, overseas sales bring income into the state thus helping the balance of payments. This is important to island areas like Hawaii that consistently incur trade deficits. If overseas agricultural earnings can be increased significantly, the trade deficit can be reduced, thus strengthening the state economy.

The third sectoral objective addresses the concern for generating additional jobs for a growing labor force, and explicitly recognizes that growth in agriculture will only occur if farming is profitable. Increases in farm employment (both self-employed and hired workers) are likely to be modest in Hawaii's present situation. With sugar and pineapple struggling to remain competitive with overseas producers, diversified agriculture must become a source of significant growth if Hawaii agriculture is to remain viable. A large portion of the diversified industries are comprised of small farm operators. If research and new technology can increase the profitability of small farmers, more entrepreneurs will be drawn to diversified agriculture. Since most of the diversified commodity industries are relatively new, and overseas markets are just beginning to be developed, farming in these industries is considered to be high risk in nature. New entrepreneurs would tend to start small-scale operations. If growth among the small farmers can be sustained, larger corporate farming may also move into the diversified industries, and the chances for successfully developing overseas markets will be enhanced considerably.

The fourth sectoral objective makes government support of diversified industries explicit, and addresses the issue of economic balance among the different islands. Growing doubts as to the continued viability of the sugar and pineapple industries, which in the past have provided the economic base of the Neighbor Island counties, and the greater availability of agricultural land in these outlying areas support the need for growth of diversified agricultural industries in the Neighbor Islands.

Sectoral objective five recognizes the present significance and future potential of agriculturally related manufacturing and service industries. These include processing industries, such as fruit drinks, processed macadamia nuts, meat products, and other processed foods, and also business services directly related to agriculture, and manufacturing and maintenance of farm inputs such as machinery, irrigation system components, fertilizer, and feeds. These activities not only are necessary to sustain growth in farm operations, but are also sources of increased income and employment growth in themselves.

2. Relevance of Socio-Economic Criteria

Sectoral objectives indicate how agriculture is expected to contribute to ultimate welfare goals. The five suggested objectives incorporate all three of the typical welfare concerns of a country or state--growth, equity, and security. For Hawaii, growth in income is stressed most, while security (of food supply) is stressed least(assuming the continuing availability of transport and communications). Equity concerns are reflected in relative emphasis to be given to support of small farmers and the Neighbor Island counties. Growth of employment is also taken into account, and the larger public welfare is addressed in terms of the increased contribution of agriculture to state income, balance of payments, and the supply of selected commodities to the domestic market. The latter implies the provision of given foods at lower prices and a positive contribution to the balance of payments via import substitution.

While it is important to establish specific sectoral goals to guide agricultural development, these are not entirely adequate for setting research priorities. For research management purposes, an evaluation of expected benefits with respect to sectoral goals is needed.

As previously noted, an approach that has been tried on an experimental basis in Latin America was the construction of a simulation model, capable of quantitatively indicating the effects of a given research proposal. In this systems approach, scientists estimate the impact of a technological innovation in terms of effects on technical efficiency, product characteristics, and production risk. With these specifications as input to the model, the estimated impacts on commodity supply, input demand, and farm consumption can be determined quantitatively. Since goals have been set in terms of these variables, the contribution of the innovation is directly determined in the model output. For each identified researchable problem any number of technological alternatives can be readily simulated.

In the case of Hawaii, and also the other Pacific islands, a large scale simulation or econometric model for the agriculture sector does not exist, and given the many commodities involved, would require a very large investment of personnel and financial resources. As previously indicated, a non-quantitative conceptual model may be devised. To make managable the task of evaluating the relative contribution (benefits) of alternative research proposals, a set of criteria consistent with the socio-economic and resource conditions of Hawaii and its agricultural sectoral goals is proposed. These criteria are used mainly to illustrate the suggested approach to research priority-setting. They are as follows:

(a) export commodity sales

(b) farm income

(c) primary and secondary employment

(d) domestic commodity sales

(e) labor productivity

(aa) new commodities

(bb) geographic impact

(cc) farm size

The criteria set (a)-(e) are the basic evaluation factors, with the set (aa)-(cc) applied on a secondary basis when relevant. Each criterion is discussed in this section; the application of the criteria for setting priorities is addressed in the following section.

For Hawaii, export commodity sales are important because of the small domestic market, especially with respect to diversified crops. Full utilization of the available acreage of relatively good cropland in Hawaii can result in production well in excess of domestic market demand. Even for crops produced and sold only in Hawaii, inelastic demand conditions result in large price declines when market supplies are seasonally high. Relatively large overseas markets tend to be much more price elastic, thus typically affording Hawaii producers more stable prices. The present conditions with respect to sugar are an exception. The peculiarities of the world market for sugar, together with U.S. policy changes since 1974, have drastically altered the stable price conditions that long prevailed.

As previously suggested, in the absence of U.S. government market intervention to stabilize U.S. sugar prices, the outlook for Hawaiian sugar is extremely dim. With satisfactory future prices and markets in great doubt, the State faces the possibility of a steady phase-out of sugar, or at least a drastic reduction, in terms of production and employment. Applied agricultural research directed toward reducing production costs will be needed to alleviate or offset the potential problems of declining sugar prices and production. Research may also be directed toward finding economically viable means of using sugar to meet domestic energy needs on a large scale, or developing viable alternative commodities which in the longer terms may be able to replace sugar.

Since the future viability of pineapple is also in question, developments and trends in export sales should be a basic criterion for future research efforts in the State. While the application of the criteria will be discussed more fully, below, it should be noted that proposed research allocations should be evaluated both in terms of the expected incremental gain in export sales as well as the prevention of potential incremental losses. That is, if development of a new technology can avert termination of productive activities, a loss in export sales is prevented, and the research contribution or benefits would be the dollar amount of export sales saved. Likewise, prevention of prospective losses in terms of the other criteria must be counted as benefits as well.

Farm income (criterion b) refers to taxable income of both incorporated and unincorporated farm operators. Farm income as a criterion recognizes the private interest of farm operators, and thus the welfare of the farm sector. Technological innovation may lead to increased productivity, but the nature of the potential technical change may have distributional implications such that consumers obtain most of the benefits (through lower prices) or certain segments of the farm operator population may not realize benefits. Such innovations may be quite desirable from society's perspective, but may not be adopted by farmers. To obtain adoption may call for government incentives or changes in economic policy.

The employment criterion refers to expected increases in farm employment (primary) and also increases in manufacturing or service (secondary) employment resulting from a potential new technology or product. An innovation which leads to large increases in the production of a given commodity may well result in the initiation of a related processing industry. Alternatively, a processing industry may already exist, and new technology may lead to increases in employment because of increased commodity production or because the innovation itself permits the processing of output which would otherwise have been uneconomical. With the continued viability of sugar and pineapple in question, prevention of losses in employment in these industries through technical innovations would be considered potentially beneficial in this context.

Criterion (d) relates to commodities which are sold primarily in the Hawaii market. These may be in competition with overseas imports or may supply the entire amount taken by the domestic market. New technology which leads to lower production costs, less production risk, or improved product quality usually results in increased production. Depending on market conditions, the innovation may produce an increase in market share and/or a reduction in price to the consumer. Increased domestic commodity sales in the face of overseas competition has an import substitution effect in that they reduce the amount of commodities that would have been imported had the innovation not been adopted.

Research management can facilitate efficient technological change by pursuing the development of new technologies which conserve on the relatively scarce factors of production, as well as addressing those commodities which are in greatest demand. This is consistent with the theories of induced innovation (Binswanger, Ruttan, Hayami, et al., 1978; and others) wherein the rate and direction of technological change may be considered endogenous to the economic system and thus may be affected by policy.

In Hawaii, as in U.S. agriculture generally, labor is the relatively scarce resource. While land prices are high in Hawaii, for purposes of long-range planning, labor may be considered the most expensive factor input. This contention is premised on continued problems in sugar and pineapple, which are likely to result in the release of significant acreages.

Although labor will also be released, the longer-term trend of relative labor scarcity is not likely to be affected because of the high average age of the sugar and pineapple workforce and increasing alternatives for work (or retirement). Therefore, in evaluating alternative research endeavors, relatively labor-saving technical change possibilities (Criterion (e)) should be given priority. Although productivity changes may be relatively labor saving, the impact of the technical change frequently leads to increased production, which more than offsets the bias against labor and results in net employment increases.

The criteria set (aa)-(cc) is intended to provide explicit consideration of factors which relate to the basic set (a)-(e). For example, it may be that a new technology enables a commodity to be produced commercially for the first time. The new commodity may result in increased export sales, as well as farm income, primary employment, and domestic sales. It may also provide diversification, larger choice for consumers, possible nutritional benefits, and additional derived demands for land, labor and other factor inputs.

Criterion (bb) responds to the concern for the special needs of the Neighbor Islands in terms of criteria (a)-(e). Likewise, criterion (cc) specifically recognizes the significance of small farms to the basic criteria set. If an innovation may have substantially greater effects on small farms in terms of (a)-(e), then the research alternative should be given additional weight.

3. Proposed Priority-Setting Process

The criteria suggested in the preceding section in effect may be treated as socio-economic indicators applicable to Hawaii, given the previously stipulated sectoral objectives. While the sectoral objectives are defined in specific terms, their usefulness for research planning and evaluation requires a methodology for measuring and comparing expected benefits of research alternatives. The criteria constitute the measurement variables, whereas the method of estimating values, summing across variables, and comparing among research alternatives provides the basis for setting priorities.

Starting point in generating researchable problems would be similar to the present Industry Analysis Program. Researchers, farm operators, extension agents and others involved in a given industry would prepare a draft assessments, and assumptions would have to be resolved. Problems constraining production and productivity would typically be addressed, but sectoral objectives and evaluation criteria would provide guidance on the specific areas of concern.

Problems in a commodity industry will necessarily relate in some way to sales, income, employment, or productivity. As the IAP is currently structured, not all problems identified require research for their resolution (e.g., lack of specific physical infrastructure, or continuation of government services which are about to lapse). Problems requiring research (researchable problems), once identified, would need to be evaluated by researchers in terms of alternative potential solutions; i.e., in terms of alternative new technologies which would eliminate, avoid, or resolve the problem.

Each problem in an industry might involve two or more potential new technologies. It should be emphasized that the terms "new technology" or "research alternative" may include a new inventory accounting method, proposed economic incentive, or revised crop forecasting system, as well as a new mechanical harvestor or high yielding seed variety.

To compare research alternatives, each must be assessed in terms of the basic and secondary criteria sets. As previously discussed, a research alternative (potential new technology) if successful, will have at least one of three direct effects; it will affect technical efficiency, product characteristics, or production risk. Physical, biological and social scientists typically will have to work together to estimate the impact of each research alternative in terms of the evaluation criteria. They must estimate which direct effects will occur and to what extent. The direct effects, in turn, will result in changes in commodity supply and demand for factor inputs. For example, a given new technology which effectively controls a pest, is likely to entail a number of effects. Crop supply will rise, pesticide and other factor requirements (such as machinery or labor to apply pesticide) are likely to increase, farm income may rise, and market price of crops may fall. Estimates of these impacts can be traced through for each criteria variable.

An example of the evaluation of two commodities, each with a problem that has two research alternatives is detailed in Table 2. The problems noted are actual ones taken from the most recent industry analyses, but in the case of the dendrobium industry, the problem has been re-worded. The balance of the information in Table 2 is hypothetical, chosen for purposes of illustrating the evaluation process. Alternative approaches and procedures may be devised in the context of a revised industry analysis process.

The problem in the macadamia nut industry is the loss of trees due to root rot. The root rot causes loss of mature trees thus reducing potential output from a given input of resources. Two alternative potential technologies have been identified to resolve the problem; the first alternative technology would be the development of a resistant tree variety, and the second alternative would require discovering the cause of the disease and developing preventive measures. Each technology, if successfully developed and adopted by farmers, would have distinct production effects. Biological and perhaps physical scientists would have to detail the manner in which the proposed technology might resolve the problem. Social scientists, interacting with the biological and physical scientists, would then estimate the cost, supply, and market effects resulting from the application of each alternative technology.

In Table 2, results of the production and economic analysis are indicated, along with estimated research costs and probability of success. In this example, an eight-year research planning period is utilized. A large part of the macadamia nut market is in the continental U.S., with increasing potential in Western Europe. Eliminating tree losses would result in larger export sales. The increase in exports attributable to the new technology is estimated for each year of the planning period. Since two or more years will be required to develop and diffuse the new technology, the impact would typically be evident in the latter years of the planning period. On the other hand, research and diffusion costs would be incurred in the earlier years. Therefore, both export sales and research costs are presented in terms of present value, i.e., discounted back to base year. For alternative one, the probability of success is estimated between 50 and 74 percent, thus the expected value (midpoint probability times present value) of export sales is used to reflect the probability of success

Table 2

Applied Research Evaluation Sheet: Fiscal Years 1983-1990

Evaluation Factors	Macadamia Nuts N						Dendrobiums N					
	Problem 4: Loss of trees due to root rot.						Problem 2: Market demand not expected to absorb large increase in production in near term.					
	Alternative 1: Develop root rot-resistant tree variety.			Alternative 2: Discover source & mechanism of infection & develop biological preventative measures.			Alternative 1: Identify new foreign markets which can be profitably developed.			Alternative 2: Develop new uses for flowers to widen existing markets.		
		Geographic	Size									
1. Export Sales[1] ($)	4.80	●	--	2.90	●	--	6.70	◕	--	7.40	◕	S-
2. Farm Income[1] ($)	.60	●	--	0.30	●	--	1.80	◕	--	1.50	◕	S
3. Employment[2]												
a. Primary	120	●	--	60	●	--	200	◕	--	250	◕	S
b. Secondary	30	●	--	15	●	--	80	◑	--	110	◕	S
4. Domestic Sales[1] ($)	1.60	●	--	0.80	●	--	2.80	◑	S	3.80	◑	S
5. Labor Productivity[3] (10^6 $)	4.8	N/A	--	2.7	N/A	--	N/I	N/A	N/I	N/I	N/A	N/I
6. Research Costs[4] (10^6 $)	0.325			0.650			0.350			0.150		
7. Probability of Success	50-74%			25-49%			>74%			50-74%		

N/A = Not Applicable.
N/I = No Impact.

Notes:

1. Measures in terms of present value of expected sales (income) over planning period divided by present value of research costs.
2. Measured in terms of estimated cumulative full-time equivalent worker-years of employment created during planning period.
3. Percentage gain in labor productivity multiplied by present value of sales affected during planning period.
4. Cumulative total cost in FY 1983 dollars. Includes diffusion costs of new technology.

Legend:

Probability of Success <25% = 25-49% = 50-74% = >74% =

New Product Y = Yes N = No

Geographic Neighbor Island Impact <25% = ◔ 25-49% = ◑ 50-74% = ◕ >74% = ●

Size S = More than half of estimated impact is in terms of small farm operators
-- = Less than half of impact is on small farm operators.

of the research. Finally, the expected present value of sales is divided by the present value of research costs, to arrive at the figure of \$4.80 for alternative one, macadamia nut export sales. That is, a \$4.80 return on export sales is estimated for each dollar of research investment. (See Appendix for the calculation procedures.)

The computational procedures are the same for estimated farm income and domestic sales. In the case of farm income, the hypothetical benefit of research alternative one is \$0.60 per dollar of research investment. For domestic sales, benefits are calculated to be \$1.60 per dollar of research. Employment effects are estimated in terms of cumulative full-time equivalent worker-years of employment generated during the planning period.

Secondary evaluation criteria also are noted in the table. Neither macadamia nuts nor dendrobiums are new products, so a capital "N" to the right of the industry name is indicated. Under each research alternative in the table, two columns indicate relative geographic impact and whether the majority (>50%) of the benefits accrue to small or large farm operators. For example, alternative two under the dendrobium industry, from 50-74 percent of the estimated gain in export sales, farm income, and employment accrue to the Neighbor Island counties, and between 25-49 percent of domestic sales are by Neighbor Island farmers. Likewise, for alternative two, more than half of the increase in export sales, farm income, employment, and domestic sales is from small farmers.

The labor productivity measure is computed by estimating the change in labor utilization to produce a unit of output before and after the innovation, evaluated at pre-innovation labor and product prices. A labor productivity gain then, would be the percentage reduction in amount of labor neeeded to produce a given amount of output. The percentage gain is then weighted by the expected present value of total sales forecast for the planning period.

In the hypothetical evaluation presented in Table 2, the return on investment in terms of sales, farm income, and employment are expected to be significantly higher for dendrobium research alternatives than for either macadamia nut alternative, but no gain in labor productivity was expected to result from the dendrobium research. In terms of secondary criteria, the research alternatives involved no new commodity industry, but in terms of geographic impact, 75 percent or more of the research benefits expected for macadamia nuts are expected to accrue to the Neighbor Islands. Alternative two of the dendrobium research is expected to be of primary benefit to small farmers, whereas in alternative one, only with respect to domestic sales would the majority of the increases go to small farm operators. The macadamia nut research alternatives both are expected primarily to benefit large farm operators.

In terms of relative overall merit, alternative two of the dendrobium research promises the highest return on research investment, and carries the added benefit of affecting mostly small farmers. In declining order of relative payoff, are alternative one of dendrodiums, alternative one of macadamia nuts, and then alternative two of macadamia nuts.

A number of observations on the proposed evaluation process are called for. An obvious difficulty arises in extending the process to the real world; in the IAP there are typically a dozen or more researchable problems identified for each industry. If each were analyzed along the lines proposed here, there undoubtedly would be many cases where it would be difficult to determine highest or higher payoffs. This is the problem of multiple objectives. Export sales may represent a very high payoff in one alternative compared to others, but the employment or labor productivity gains may be very small or nil. That is, among alternatives there may be many instances in which large returns for certain variables are offset by little or no gain in other variables. Selecting one alternative in lieu of another would involve trade-offs, e.g., taking large gains in employment, but foregoing a substantial increase in export sales.

Weighting schemes or scoring techniques may be used to sum across criteria variables, such that each alternative is ultimately assigned a single value. These values then become the basis for ranking all alternatives from highest to lowest. However, the selection of weights or scores can in itself be biased by preferences of the analysts or the greater availability of certain statistical series. Rather than taking a weighting approach, it may be better to evaluate the alternatives as in Table 2 and then submit them to a selected panel of research administrators, scientists, planning officials, and sectoral representatives. It would be their task to evaluate the trade-offs, and relative strengths and weaknesses among variables, and seek to arrive at consensus agreements on the relative merits of each alternative. Thus the panel or committee would establish an ordering or ranking of proposed research alternatives, based on a more systematic evaluation of socio-economic criteria as related to agreed-upon sectoral planning objectives.

It should be noted that the relative size of an industry (total sales) will obviously have a bearing on the amount of benefits produced. Successful applied research adopted in a large industry will result in large returns to investment costs, since a given innovation will have more extensive application. Therefore, research investment should have a tendency to flow into the various industries in proportion to their relative size. Of course, such factors as stage of development, unanticipated changes in business or production environment, and scientific breakthroughs in applying the results of basic research can result in opportunities in smaller industries that lead to relatively large applied research returns.

Some anticipated problems in applying the approach suggested here relate to difficulty in estimating research effects on criteria variables, length of planning period, difficulty in estimating probability of research success, the effect of a low probability estimate, the choice of the criteria, and method of application.

Presently a great deal of effort goes into the IAP program, but there has been no particular focus on sectoral goals or sector-wide criteria. Effort is conditioned to a large extent by the profitability interests of the industry, as is to be expected. While industry perspective is necessary and important, the larger public interest should also be represented. Admittedly the criteria variables will be difficult to estimate, but the same is true of judgments of industry potential and effects of not eliminating a bottleneck, variables which are now addressed in the industry analysis. A basic premise of the suggested approach is the ability of scientists to predict the effect of their research with sufficient degree of accuracy to justify the resources invested in the effort.*

The length of the planning period for applied research must consider the time required to complete research projects, put successful results in useable form, disseminate the new technology, and realize the benefits.

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*Individual scientists conceive their research proposals on the basis of expected benefits. While it is true that self-interest influences the proposal, ex post evaluations for many applied research programs in agriculture have shown consistently higher returns. The contention here is that an organized, systematic effort to select proposals will produce higher returns than the conventional research review and approval processes.

Cutting the period too short minimizes expected benefits, while lengthening the period increases the difficulties in predicting estimated benefits. Defining the optimum period is difficult. The eight-year period used to illustrate the approach, while not unrealistic for farming enterprises, was largely an arbitrary choice.

The probability of success estimate for a given research proposal was previously discussed. In the process of setting priorities, a low estimate may result in a subjective bias against the proposal. One way to avoid the problem might be to not disclose the probability estimate on the evaluation sheet submitted to the final decision-making panel. Even if low probability research projects do not meet planning objectives, the investment is not necessarily wasted. Learning benefits accrue, and in some instance, the results are found to be beneficial in other research areas or in unanticipated applications.

Choice of evaluation criteria and method of application have been suggested primarily to illustrate what is believed to be a useful approach to applied research management. What is important is the establishment of agricultural development objectives which are responsive to and compatible with social, economic, and environmental conditions. Evaluation criteria should not only be consistent with sectoral objectives, but must also be defined in terms of measures (variables) which facilitate the comparison of benefits among research alternatives and the weighing of trade-offs. It appears obvious that much more research on choice of socio-economic criteria and their utilization is needed before a workable research planning and evaluation system can be put into place. The suggested listing is intended to stimulate this process.

4. Organizational Aspects

Utilizing the approach to planning and evaluation presented in the previous section, research management can set priorities among alternatives on a more systematic basis. Decisions on resource allocation can be made on the basis of expected returns on investment as measured by the criteria variables or socio-economic indicators. The process could be utilized not only by CTAHR in carrying out its current research responsibilities, but also by GACC in broader areas of agricultural resource allocation and by DOA and other agencies in performing mandated functions of the State planning process.

Industry participation is obviously essential as it is in the IAP. It needs to be augmented with inclusion of heretofore unrepresented groups. But if the priorities are established by public administrators, will industry support and participation continue? The answer may depend on how much impact the industry thinks the existing analysis has on public decisions to address the research and other problems indentified in the analysis. The strength of continued industry support would also depend on how responsive it felt a new priority-setting system would be to its problems.

It can be argued that a more visible, systematic process of priority-setting would be viewed favorably by most members of the industry. A significant problem with the IAP is its informal structure and lack of explicit procedures and information on allocated resources. Like any other research project, planning and evaluation of applied research should have formal status and budgeted personnel and funds. Faculty and staff personnel in CTAHR should have specific time commitments and responsibilities for participation or leadership of analysis groups. Such commitments could be on a part-time or released-time basis for most participants. Similarly, participation of other state agency personnel should be on the basis of formal commitments. Presently, many state agencies (and division and branches within agencies) are under-represented in the analysis groups, and very often this constrains the analysis because the agencies not represented have jurisdiction on programs directly related to the identified problems.

Along with formal program status, research planning and evaluation should adopt administrative procedures related to industry and other public participation. Increased public awareness and participation in information meetings and hearings would provide valuable feedback in considering general public concerns and in assessing alternative technologies. Administrative procedures and distribution of information should also be designed to specifically encourage the participation of small farmers and persons interested in entering agriculture.

The research evaluation approach outlined here does not encompass basic research. This shortcoming does not imply that basic research is of little concern. The importance of basic research in generating technology potential has been discussed. Also, U.S. policy has placed increased emphasis on providing technical assistance to friendly less-developed countries. Technical assistance to other Pacific island areas which have tropical conditions but virtually no agricultural research capability is an identified need. Both basic and applied research are required to support such overseas technical assistance.

It should also be noted that a systematic priority-setting process, which is applicable to all research alternatives, and which specifically considers research costs should coincide with the public budgetary process. The budgeting of applied research funds would necessarily have to be in conjunction with the overall executive budgeting process of each state agency. As with the IAP, the proposed planning and evaluation system cuts across agencies. The GACC would thus continue to be responsible for coordinating agriculture-related programs, projects and budgets.

The process of planning and evaluating research alternatives in accordance with socio-economic indicators which are related to projected research costs (investment), would also generate financial data for state agriculture functional planning purposes.

5. Policy Implications

Adoption of an approach to research priority-setting similar to that illustrated in this report, would resolve a deficiency recognized in the State Agriculture Plan, bring about a closer relationship between planning and research activities, and result in more efficient and effective research decision-making. Substantial changes in the current method of decision-making certainly would entail significant costs, much of which would be start-up or development costs. The benefits of the proposed approach would be realized in a significantly larger contribution of research to agricultural development, for a given expenditure of resources.

The rigorous derivation of research criteria or socio-economic indicators, consistent with sectoral objectives and based upon resource, social, and economic conditions relevant to agriculture, provides a sound basis for evaluating all research alternatives, regardless of industry. Focusing on operationally defined criteria should produce better analysis. In many instances, this may require scientists to actively seek additional information directly from farmers and others. This suggests the more obvious need for social, physical and biological scientists to work together, and with farmers and others involved in agriculture, to identify problems, explore alternative technologies, and estimate the differential impacts of alternative approaches. (FSR&D has been widely heralded as a logical means for dealing with this issue.)

Implementation of the proposed approach would call for a number of of specific actions. In terms of organization, the research planning and evaluation program should be given formal program status, with corresponding budget, personnel assignments, administrative procedures and practices, and an initial organization structure designed to coordinate the various commodity industries, resources and critical problem areas. The IAP already incorporates a commodity-oriented structure.

Another action would involve the development of a more complete set of socio-economic indicators for evaluation purposes, expanding upon those proposed in the illustrative example. To ensure consistency with sectoral objectives and State Plan goals and objectives, the State Agriculture Plan would need some modification.

In addition to CTAHR research program administration and participation of scientists, firm commitments for personnel participation of other state agencies would be needed. As noted previously, these commitments should be made in accordance with formal interagency agreements.

Industry support and participation is critical; therefore, continuing attention needs to be given to means of encouraging and motivating the widest possible participation--especially in substantive contribution to problem identification and analysis. As in the IAP, the fact that public resources are being committed to support industry problem-solving should be a strong motivating factor. However, additional means of encouraging participation by small farmers, prospective farmers, and others involved in non-farming agricultural businesses may be needed.

Increased resources probably will be required for the analytical process of identifying significant researchable problems, and evaluating the expected impact of potential alternative technologies. However, the expected higher returns to research investment should far outweigh the additional resources spent on improving the priority-setting process. In the initial implementation stage, it will probably be necessary to address a limited number of commodity industries, building upon the knowledge already gained in the IAP. The larger industries most recently analyzed would be appropriate candidates.

The use of quantitative models for evaluation and planning purposes was discussed earlier. Large-scale models encompassing the entire agriculture sector would be very costly and require a large amount of time and expertise to develop. However, developing conceptual, non-quantitative models or constructing smaller-scale models for particular commodity industries may be productive over the long-term. Starting with one or two relatively important industries, quantitative planning models could be developed gradually. The learning experience and the analysis generated in the interim would supplement the primary analysis being conducted by more conventional (partial equilibrium) methodologies. Ultimately, the availability of statistical data, improvements in the state of the arts in modeling, and reduced costs of computer utilization, may encourage a greater reliance on a quantitative systems approach.

The implementation of the proposed priority-setting process, which amounts to an extension of the present IAP, obviously has budgetary policy implications. If the planning and evaluation are completed for all research alternatives,* budgeting should be consistent with the priorities established on the basis of the evaluations. If the state executive budget process is conducted without regard to the priorities indicated by the evaluation results, the return on state resources invested in research will fall short of the indicated potential.

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*During an initial transition period, relatively few commodity industries will have been evaluated; thus funding decisions will have to be made on many projects without the benefit of the kind of evaluation proposed here.

APPENDIX: CALCULATION PROCEDURES FOR TABLE 2

The methodology to derive the values in Table 2 is straightforward and can best be explained with an example.

The value of \$4.80 for Export Sales of macadamia nuts was calculated as follows:

I. Selection of Discount Rate

The rate selected would be the long-term borrowing rate for government (e.g., general obligation bond rate for State of Federal long-term bonds), or an estimated long-term rate of return on capital investment. In this hypothetical situation, a 10% discount rate will be used.

II. Forecasting Sales (or Benefits)

a) Two forecasts are required. The first would predict sales, should the bottleneck or problem under consideration be alleviated. The second forecast would reflect sales as expected should the bottleneck remain. The judgments underlying these forecasts could be tested against other expert opinions.

b) The difference between these two values would be the portion of benefits attributable to the technical innovation necessary for the alleviation of the problem. In this example, the difference in forecasts on a year to year basis, using a discount rate of 10%, is calculated to yield a Net Present Value in a base year.

c) Net Present Value (NPV) multiplied by the midpoint probability of success ($[.50 + .74] \div 2 = .62$ in this example) yields the Expected Value of Sales Due to the Technological Innovation.

III. Forecast on Research Costs (see Appendix Table 3)

In this example, an 8-year forecast of the research, development, and dissemination costs of generating the technical innovation is made. In this hypothetical problem, the forecast discounted back to the base year yielded a NPV of $325,000 (see Table 2).

IV. Estimated Return on Sales for Each Dollar of Research Investment (see Appendix Table A)

$$\frac{[\text{Mid-point Probability of Success}]\ [NPV_S]}{NPV_R}$$

where NPV_S = Net Present Value of Sales Due to Technical Innovation

and NPV_R = Net Present Value of Research Cost

The other evaluation factors, i.e., Farm Income, Employment, Domestic Sales, etc., would be calculated in a similar manner aside from a few alterations.

Farm Income includes wages and salaries. (IRS treats proprietorship and partnership "wages" as part of taxable income, whereas employee wages and salaries are a farmer's expenses and hence not a part of taxable income for the corporation). Basically the procedure would involve two forecasts of "farm income" for the 8-year period--<u>with</u> and <u>without</u> innovation. The year-by-year difference is discounted back to the base year and multiplied by the mid-point of the probability of success.

Employment can be calculated using the same procedures, but requires forecasts of cumulative number of FTE (full-time equivalent) worker-years

TABLE 3

Forecast of Export Sales ($10 million)								
	1983	1984	1985	1986	1987	1988	1989	1990
Without Technical Innovation	20.00	20.50	21.13	21.82	22.86	24.00	25.15	25.83
With Technical Innovation	20.00	20.70	21.57	22.35	23.49	24.75	26.00	26.70
Forecasted Gain via Adoption of Innovation	0	.20	.44	.53	.63	.75	.85	.87

$$NPV = \sum_{n=0}^{N} \frac{P_n}{(1+i)^n}$$ using 1983 as the base year for the 8 year period with interest rates at 10%.

$$NPV = \frac{0}{1.1} + \frac{.20}{(1.1)^2} + \frac{.44}{(1.1)^3} + \frac{.53}{(1.1)^4} + \frac{.63}{(1.1)^5} + \frac{.75}{(1.1)^6} + \frac{.85}{(1.1)^7} + \frac{.87}{(1.1)^8} = 2.5142$$

Estimated Return on Export Sales per Dollar Invested in Research:

$$\frac{(\text{Mid-point Probability of Success})(NPV_S)}{NPV_R} = \frac{(.62)(2.5142)}{.325} = 4.80$$

employment <u>with</u> and <u>without</u> innovation for both primary and secondary employment.

Domestic Sales can also be calculated using the same procedures as Export Sales.

Labor Productivity is the forecast of percentage gain (or loss) in labor productivity (input per unit of output). A gain occurs when the number of hours of labor required to produce a given amount of output is less <u>after</u> the innovation. A single commodity, macadamia nuts for example, could use value of labor input (because of non-homogeneous labor) per 1,000 pounds of macadamia nut output. After weighted average percent gain (or loss) in productivity is estimated for the 8-year period, this percentage is multiplied by NPV of the Total Commodity Sales (both export and domestic).

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